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THE ARRHENURI OF THE UNITED STATES

By RUTH MARSHALL

WITH SIXTEEN PLATES

I

The Arrhenuri comprise the largest genus of the Hydrachnidæ, and one of the most highly differentiated and widely distributed. The genus is easily recognized by the following characters. The thick chitinous covering of the body is pierced by large pores. A circular furrow on the dorsal side marks off an area which is entirely enclosed in the female, in the male usually open onto the posterior extension of the body. The females are oval in form and much alike; the males are smaller and vary greatly from each other and from the females. They are characterized by a posterior prolongation of the body of varying length and complexity called the appendix, at the end of which there is often developed an accessory sex organ, the petiole. The epimera are in three groups. The capitulum has the form of a shield with a wedge-shaped notch closed by a membrane. The genital cleft in the female is flanked by two large semicircular discs, from each of which extends a wing-shaped area covered with small acetabula. The male genital area, at the base of the appendix, has narrow plates forming an elliptical plate for the cleft, from which extend narrow wing-shaped areas. The palpi are short and stout, ending in a pincer formed by the fifth segment and a prolongation from the distal end of the fourth. The legs are relatively short and much alike throughout the genus; the last three pairs have swimming-hairs, and the fourth segment of the fourth leg in the male usually has a spur bearing a bunch of hairs.

The Arrhenuri vary in size from something more than half a millimeter to over two millimeters in length. The color is usually dull blue green, less often dull orange red—colors which harmonize with the environment of these mites, which are shore and bottom

forms, found in shallow clear waters where chara and other water plants are abundant.

The species fall into three, or perhaps four, large groups, according to the development of the appendix and its structures in the male; these groups have been designated as subgenera. There is first the simple type in which the body form approaches that of the female, the appendix slightly developed and the petiole absent; this is the type of the subgenus *Truncaturus* Thor. From this simple type there appear to have been three divergent lines of development, two of which have produced "short-tailed" Arrhenuri, and one "long-tailed." The latter, the subgenus *Megalurus* Thon, has the appendix enormously elongated, but comparatively simple in structure and lacking the petiole, at most having no more than a rudiment of it. The subgenus *Micrurus* Thon has a short appendix with a deep median incision, over which lies a petiole and certain hyaline structures. The third type to be differentiated has an appendix of varying length with prominent posterior lateral corners and a conspicuous petiole and accessory structures. This group, which appears to be the most highly differentiated as well as the largest in species, is the subgenus *Petiolurus* of Thon. Wolcott (1905) has pointed out, however, that this name should be changed to *Arrhenurus,* as the subgenus contains the type of the genus. The four subgenera are not sharply marked off from each other, there being intermediate species difficult to assign to any one group.

One hundred and forty-seven species and varieties of the genus are already recognized, of which nineteen have been described from the females and immature males only. Besides this number, there are over fifty species which are designated by Piersig as doubtful, the work chiefly of earlier writers.

The greater number of species described are European, as might be expected. As far as work on the Arrhenuri of the rest of the world has gone, it reveals the fact that each continent has its own peculiar fauna; the same subgenera are to be recognized in each case, but the species are distinct. The only exception to this is the occurrence of five European species in Asia Minor; but this region may be regarded as biologically a part of Europe. Three new species have been described for Asia Minor and eight others from

Ceylon, Java, and Dutch New Guinea; twenty-two have been described from Africa; nine for South America, and sixteen for North America.

It will be seen that the Arrhenuri of the Western Hemisphere have received but little attention. The first work on any North American water-mites was done by the eminent German hydrachnologist, Dr. F. Koenike. In 1895 he published descriptions of four new Arrhenuri; the material for the study was collected by Dr. J. B. Tyrrell in British Columbia. In 1903 the author described ten species, and in 1904 added two more, the material coming from Wisconsin and Massachusetts. Of these twelve species, all belonging to the subgenus *Megalurus,* half were identified with European forms; but it was at once pointed out by Dr. Richard Piersig of Germany, a recognized authority on hydrachnids, that these also were new species and they were consequently so christened by him.

Material for the study of the Arrhenuri of the United States embodied in this paper has been secured from eighteen states, the largest part from the Middle West. The author's own collecting has been confined to Wisconsin, where over forty bodies of water were visited. To this material valuable collections from New Hampshire and Vermont were added by Mr. George D. Nourse; from Oregon by Dr. Elda R. Walker; from Louisiana by Mr. E. Foster; and from Maine by Mr. A. A. Doolittle. A great part of the material, however, came from the large collection of water-mites belonging to Dr. Robert H. Wolcott, who generously allowed the author to work out the Arrhenuri. Dr. Wolcott's personal collections were made in Michigan, Missouri, Nebraska, Wisconsin, New Hampshire, Colorado, Indiana, Massachusetts, New York, and Ohio, chiefly in the three first-named states. Other collections were added to these, the chief of which were those of the State Biological Station at Havana, Ill. Dr. Wolcott was also fortunate enough to secure material from Dr. Henry B. Ward, from Illinois, Michigan, and Nebraska; from Dr. C. Dwight Marsh, from Michigan; from Dr. Chas. Fordyce, from Nebraska; from Mr. E. Foster, from Louisiana; from Miss Caroline E. Stringer, from Nebraska; from Mr. J. C. Crawford, from Nebraska; from Mr. O. D. Noble, from Nebraska; from Mr. A. S. Pease, from Nebraska and Massachusetts; from Mr. A.

J. Coats, from Wisconsin; from Prof. J. G. Needham, from Illinois; from Mr. J. B. Shearer and Dr. R. H. Ward, from Michigan; from Mr. R. S. Gray, from California; from Mr. E. W. Berry, from New Jersey; from Mr. R. H. Johnson, from New York; from Prof. S. A. Forbes, from Yellowstone National Park; and from Dr. Alfred Dugès, Guanajuato, Mexico.

In this large amount of material over three thousand individuals of the genus have been identified and described. The four subgenera were represented by a total of forty-six species, thirty-six of which are new. The subgenus *Megalurus* has the largest number of species, and a majority of all the individuals; in Europe the subgenus *Arrhenurus* is the richest in species. It is significant that Wisconsin, the state in which the largest number of collections were made, has twenty-six, or over half the number of species present. To this number might be added three other species previously described by the author from this state, but not recurring in the later collections. It is reasonable to suppose that more extensive collecting will bring to light other species and a wider range for those already described. The total number now known for the United States is about half the number found in Europe. The females are known in ten species.

II

Descriptions of the Species

The species are put in their subgenera, and an attempt is made to arrange them in natural groups.

Subgenus Truncaturus

No species were found as undifferentiated as *A. knauthei* Koen., designated by Thor as the type. The five species here grouped together have each a small simple appendix, but no petiole or accessory hyaline structures. The end of the appendix has a median incision of varying depth, and consequently this group stands near the next subgenus; the dorsal median surface is likewise more or less depressed. The body is regularly oval, with no large humps, though slight elevations bearing hairs are found where the appendix joins the body. There is a slight bulging over each eye, the

genital wings are broad, and the dorsal enclosed area is large. The fourth leg of the male bears no spur on the fourth joint. These Arrhenuri are relatively small. To this group belong:

A. rotundus n. sp.
A. ovalis n. sp.
A. crenellatus n. sp.
A. bicaudatus n. sp.
A. acutus n. sp.

Arrhenurus rotundus n. sp.

Pl. VII, figs. 1-4; pl. IX, fig. 128

Arrhenurus rotundus has a form approaching that of the African species *A. pectinatus* Koen, with a narrow, slightly indented appendix. In the depth of this shallow incision lies a papilla. The greatest width of the body is found just anterior to the enclosed dorsal area; the latter region is slightly depressed, the sides of the furrow turning out to end at the genital wings. These areas project slightly over the body wall; the anterior borders are indistinct. The third epimera have very narrow inner borders. At the point where the appendix joins the body there are two low humps, each with a fine hair. There are four pairs of long hairs on the end of the appendix, and shorter ones on the body; the arrangement is best shown by the figures. The palpus closely resembles that of *A. manubriator,* the fourth joint being somewhat rectangular in outline. The fourth leg is very simple in structure.

Female. The body is an ellipse, bulging slightly at the anterior end. The dorsal enclosed area is ovate, very narrow in front, with a concave posterior border. A lateral view shows the body moderately arched with no humps. The third epimera shows the same peculiarity as in the male, a very narrow inner edge. The genital plates are large, the wing-shaped areas wide and short and directed obliquely back. The males measure 0.83 mm. in length and 0.68 mm. in width; the females are 1.09 mm. long and 0.98 mm. wide. The color varies with age from dull yellow to orange red.

Twenty-seven males and fifty-eight females occurred in eight collections, all but one being in the same region. These collections were made in the fall of 1905 in small pools near Lake Winnebago

and the city of Appleton, Wisconsin. One collection was also made June 2, 1906. The other locality, where was found one male, was the mill-pond at Big Spring, Adams county, Wisconsin, Aug. 17, 1905.

Arrhenurus ovalis n. sp.

Pl. VII, figs. 5-7

Arrhenurus ovalis male is closely related to *A. setiger* Koen., described from Canada; it is larger, however, and the appendix is slimmer. The body is nearly elliptical; the genital wings, wide at their origin, run some distance up on the dorsal side. The area inside the dorsal line is elevated; it extends well over on the appendix, where it is narrow and completely enclosed by the furrow. The low appendix has a distinct though small median incision with a small papilla in the depth; the outline shows three low scallops on each side, the posterior two belonging to the depressed central region. There are two pairs of fine hairs on each side. The length is 0.93 mm., the width 0.75 mm. The color is dull yellow green.

Two individuals of this new species are known. One was found in a small pond near Appleton, Wisconsin, September 28, 1905; the other was collected by Dr. R. H. Wolcott at High Island Harbor, Michigan, August 18, 1894.

Arrhenurus crenellatus n. sp.

Pl. VIII, figs. 11-13

This new species, like the preceding, is closely related to *A. setiger* Koen., from which it differs in several details. There is a slight indentation between the eyes; the area inside of the dorsal line is depressed and the genital wings are of nearly the same width throughout. The appendix has the same general form as in the related species, but the indentation at the end is broader. The dorsal depressed surface bears a little peg-like structure (A) placed obliquely; this was not always present, however, in the material examined. The dorsal shield is oblong and entirely enclosed, the furrow running out on the base of the appendix to form two scallops which enclose each a little hump. The palpus is unusual; the second segment, which is very large, bears a dense area of blade-like hairs

on the inner surface. The length of this mite is 0.84 mm.; the width 0.68 mm. The color is dull yellowish green.

Thirty-seven individuals occurred in small numbers in collections from three states, as follows: Wisconsin—Lake Mason, near Briggsville, August 16, 1905; Buffalo Lake, at Packwaukee, September 5, 1904; Lake Wingra, Madison, August 29, 1905. Michigan —Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott); Les Chenaux Ids., August, 1895 (Mr. J. B. Shearer); Grand Rapids, summers of 1895 and 1897 (Dr. R. H. Wolcott). New Hampshire —Charlestown, summers and falls of 1905 and 1906 (Mr. G. D. Nourse.

Arrhenurus bicaudatus n. sp.

Pl. VII, figs. 8-10

The body of the male is obovate, narrow in front of the eyes, where it is slightly indented. The dorsal shield is large, oval and elevated, the ends of the furrow bending out to lose themselves on the base of the appendix. The fourth epimera do not have as pronounced posterior angles as do those of the related species. The genital areas are unusually wide and extend slightly over toward the dorsal surface. The narrow appendix is well marked off from the body and is narrow. There is a central deep incision in which are seen a few very small hairs; this incision divides the appendix into two large lobes. Anterior to the incision, where the appendix is low, is a triangular depression (A); the two anterior angles have little rounded projections (B), and in front of these are two little points (C) and a pair of fine curved hairs. This species is the smallest in the collection, the length being 0.75 mm. and the width 0.62 mm. The color is dull orange.

Only four individuals of the species are known, but the range is wide. The collection of Dr. R. H. Wolcott contained three; one found in Eagle Lake (Winona Lake), Indiana, July 30, 1903, and two in Lake St. Clair, Michigan, in the summer of 1893. A fourth was found in the Calcasieu River, Louisiana, by Mr. E. Foster, September 11, 1906.

Arrhenurus acutus n. sp.

Pl. VIII, figs. 14-16

Arrhenurus acutus is a rare form closely resembling *A. bicaudatus* in the form of the appendix, but most readily distinguished from it by its greater size. The body is elliptical; besides the slight bulging out over each eye there is a slight protuberance anterior and internal to this, a character so often found in the next subgenus. The dorsal enclosed area is large and elevated; the furrow bends inward at the anterior end and is lost on either side when it bends out to meet the genital wings. The genital areas are very wide and scarcely reach the lateral surfaces of the body; the anterior borders are very indistinct. The appendix is divided into two acute lobes, by a large, deep rounded incision, in the depth of which are a few very small hairs. On the dorsal depressed surface in front of this incision is a large triangular hollow (A), the anterior wall of which is very sharply defined and has at each end a rounded corner (B). A little forward of this wall is a tiny point (C) on each side, and a fine curved hair. Thus the structure of the appendix closely resembles that of the related species. On each side are three long hairs and two short ones. The length of the animal is 0.99 mm., the width 0.75 mm. The color is dull brownish yellow in the preserved material.

Only two individuals of the species are known. One was found in Mirror Lake, at Delton, Wisconsin, August 21, 1905; the other in the collection of Dr. R. H. Wolcott in Soft Water Lake, Grand Rapids, Michigan, August 4, 1896.

Subgenus Micrurus

This subgenus, for which Thon designated *A. forpicatus* Neuman as the type, has a general oval outline, but it shows a tendency to produce protuberances over the eyes and humps on the dorsal surface. The dorsal shield is small and completely enclosed. Over the median incision of the appendix lies a petiole; in the species studied this springs from a hollow in the center of the depressed dorsal surface which appears to be a continuation of the dorsal furrow, all of this area presenting a complex structure. The subgenus

is represented in the present collections by five new species, all of which are rare:

A. scutulatus n. sp.
A. infundibularis n. sp.
A. lyriger n. sp.
A. laticaudatus n. sp.
A. montifer n. sp.

Arrhenurus scutulatus n. sp.

Pl. VIII, figs. 17-19

The body of this new form is nearly oval in outline, slightly bulging over each eye and moderately arched in the center. The dorsal shield, which is very small, has an unusual form; it is broad, indented at the anterior end and constructed abruptly behind to broaden out again on the appendix into a somewhat four-sided elevated piece. The genital wings have an unusual outline on the posterior border, each broadening out strongly half way between the plates and the outer end; they extend well over toward the dorsal side. The appendix is large and very broad, the two lobes formed by the median incision simple in outline. In the center of the depressed dorsal area there is a hollow (A), inverted heart-shape; the petiole, which springs from this, is a funnel-shaped hyaline structure (B), directed outward, the ventral surface strengthened by a spoon-shaped piece. Three pairs of fine hairs grow on the appendix, and another pair at the end of the enclosed dorsal area. There is no spur on the fourth joint of the fourth leg. The length of this mite is 0.85 mm. and the width 0.67. The color is dull blue green.

But four individuals are known; these came from as many different localities, as follows: Wisconsin—Green Lake, September 9, 1905; Buffalo Lake, at Packwaukee, September 5, 1904. Michigan —Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott); Saginaw Bay, August, 1895 (Mr. J. B. Shearer).

Arrhenurus infundibularis n. sp.

Pl. VIII, fig. 20; pl. IX, figs. 21, 22

Arrhenurus infundibularis bears a general resemblance to *A.*

scutulatus; the appendix, however, is more sharply differentiated. The oblong body bulges out strongly over each eye, with two median protuberances. The small dorsal shield is oval, the posterior end indented; the enclosing furrow is wide at the rear and runs over into the hollow of the appendix. In the middle region of the body are two low humps, seen best in lateral view, marking the greatest elevation of the body. The third epimera are slightly wider on the inner edge than are the fourth. The genital wings are narrow and extend a short distance toward the dorsal side of the body. The appendix is well marked off from the body; the median incision is deep and narrow. The hollow (A) on the depressed dorsal face is large and circular, and connects with the dorsal furrow as already noted. From the anterior end of this springs the large hyaline petiole (B), in shape like a funnel, the rim of which has been flattened down on the upper side. Two fine hairs lie on the face of this structure. The fourth leg lacks the spur. The length of the body is 0.9 mm. and the width 0.68 mm. The color is dull blue green.

Six individuals have been found in as many different collections; the range, however, is wide. Wisconsin—Portage, the canal, August 24, 1905. Michigan—Intermediate Lake, Ellsworth, August 9, 1894 (Dr. C. D. Marsh); Lamberton Lake, Grand Rapids, July 22, 1898 (Dr. R. H. Wolcott). Missouri—Rocheport, Roby's Pond, July, 1904 (Dr. R. H. Wolcott). Oregon—Forest Grove, Todd's Pond, August 7, 1906 (Dr. E. R. Walker).

Arrhenurus lyriger n. sp.

Pl. IX, fig. 26; pl. X, figs. 27, 28

The complex and unusual development of the dorsal face of the appendix separates this *Arrhenurus* clearly from any previously described species, although it is closely related to the two preceding. The body is almost circular in outline, except for the bulging over each eye and the two median protuberances which are close together. The body rises to a low cone on each side in the middle region, as seen in a lateral view. The dorsal enclosed area is very small, somewhat seven-sided. The furrow which encloses it runs into the depressed part of the appendix. The third epimera are slightly broader at the inner ends than are the fourth. The genital

wings are rather wide; they extend up on the dorsal body wall. The moderately large appendix has a deep median incision, partly covered by the large petiole. The dorsal depressed area of the appendix is broadly triangular, the apex at the end of the dorsal shield. Near the apex on either side are two prominent rounded projections (A), extending over onto it, the posterior bearing a long, fine hair. In the center of the depression lies a very complex hyaline structure and petiole. The former is a flat, somewhat triangular sac (B), cleft on the upper side, and seemingly wrapped around the thick stem of the petiole (C), whose shape at the end is that of an inverted harp. Two fine hairs arise near the end of the cleft of the hyaline structure, and two more from a pair of small humps placed one on each side of the end of the petiole. Other fine hairs are best shown by the drawings. There is no spur on the fourth leg. The length of the entire body is 1.00 mm.; the width is 0.79 mm. The color is dull blue green.

Six males of the species were found in five collections from four different states, as follows: Wisconsin—Green Lake, mill pond, September 9, 1905. Michigan—Grand Rapids, summers 1895 and 1896 (Dr. R. H. Wolcott). Missouri—Rocheport, Roby's Pond, July 24, 1904 (Dr. R. H. Wolcott). New Hampshire—Charlestown, August 20, 1905 (Mr. G. D. Nourse).

Arrhenurus laticaudatus n. sp.

Pl. IX, figs. 23-25

This *Arrhenurus* presents a very unusual form because of the great width of the appendix and the strong arching of the body. The anterior region bulges out over each eye, with two median protuberances besides; back of this the body keeps nearly the same width to the appendix. The enclosed dorsal area is small, the posterior end greatly elevated at two points (A). The body is highest just outside of the furrow, where it rises into a large cone on each side. The genital areas are narrow and scarcely projecting. The first and second epimera are bluntly pointed; the fourth is unusually small, its inner border being narrower than that of the third. The appendix is wider than the body; it rises on each lateral border to form a triangular platform (B). In the center of the depressed

dorsal area is a broadly oval hollow (C) in which lies a bladder-like sac of similar shape with a rounded structure on top of it, the latter bearing on each side a short hair. These structures represent the petiole. The hollow is connected by a crease (D) with the broad dorsal furrow. The median incision of the appendix is small and rounded with a tiny point in the center. Four pairs of hairs, two long and two short, are placed near the end of the appendix in the center. The fourth leg bears a spur. The length of the body is 1.14 mm.; the greatest width, at the appendix, is 0.85 mm. The color is dull yellow.

Eight individuals of the species have been found in the following collections: Green Lake, Wisconsin, September 9, 1905; Fisk's Lake, near Grand Rapids, Michigan, September 8, 1894; Roby's Pond, Rocheport, Missouri, July 24, 1904. The last two collections were made by Dr. R. H. Wolcott.

Arrhenurus montifer, n. sp.

Pl. x, figs. 29-31

This rare and unusual form is at once recognized by the wide appendix, greatly elevated dorsal shield and peculiar and complex petiole. The body, slightly obovate, bulges out over the eyes, with two median protuberances. The dorsal enclosed area is indistinctly pentagonal; it is greatly elevated above the rest of the body, rising into a cone which has a little hump on each side, and falling to the furrow behind, which is here rather wide. The first and second epimera are bluntly pointed; the fourth has a narrow inner end and a pronounced posterior angle. The genital wings are narrow, and reach barely to the sides of the body. The appendix flares out from its base to become as broad as the body. The depressed dorsal area is long and narrow, making the appendix appear composed of two layers, each of which ends in lateral scallops, the ventral being longer and narrow. The median incision is very small. The petiole is large and stout; it arises from a longitudinal crease in the center of the appendix. There is an obliquely placed cylindrical base (A), with a pair of fine anteriorly directed hairs, on the dorsal face of which lies a heavy rod-like structure (B), also placed obliquely. From the ventral side of the latter extends a thin irregu-

larly shaped vertical transparent plate (C). The entire length of the animal to the end of the petiole is 1.12 mm.; the width, 0.76 mm. The color was lost in preserving.

A. montifer is represented by one individual in the collection from the Illinois State Biological Station, from Havana, Illinois, April 3, 1895.

Subgenus Megalurus

In the Arrhenuri of this group the appendix is at least more than half as long as the body alone. It is comparatively simple, however, and bears no petiole, unless certain small structures developed in a few species be taken as the beginnings of such. The body is ovate or obovate, but does not usually show very pronounced elevations. The fourth leg is relatively long and its spur is usually well developed. A comparison of the described species as shown by published drawings, together with a careful study of the species in the present collection, brings out the fact that three types are present, though not sharply defined. These three types or series will be designated for convenience by the first three letters of the alphabet. In series A the appendix does not attain its greatest length, and the end is decidedly narrower than the base. Series B shows a tendency to widen the posterior end of the appendix, while the body may develop small elevations, and the dorsal shield is depressed. In series C the appendix keeps much the same width throughout, but attains its greatest length; there is a tendency toward the development of humps on the dorsal side and an elaboration of the end. The nineteen species here represented will be grouped as follows:

Series A	Series B	Series C
A. birgei Mar.	*A. capillatus* n. sp.	*A. pseudocaudatus* Piers.
A. mamillanus n. sp.	*A. manubriator* Mar.	*A. prominulus* n. sp.
A. solifer n. sp.	*A. marshalli* Pier.	*A. krameri* Koen.
A. scutuliformis n. sp.	*A. megalurus* Mar.	*A. rectangularis* n. sp.
A. pseudocylindratus Piers.	*A. parallelatus* Mar.	*A. semicircularis* Piers.
	A. expansus n. sp.	*A. longicaudatus* n. sp.
		A. cornicularis n. sp.
		A. apetiolata Piers.

Arrhenurus birgei Mar.

1903. *A. birgei* Marshall, Trans. Wis. Acad., xiv:158-159, pls. 16-17, fig. 10.

1904. *A. birgei* Marshall, Trans. Wis. Acad., xiv:520-521.

A. birgei appears to be the least differentiated member of the subgenus, the appendix being simple and relatively short. It is likewise the smallest member of the group in these collections.

The species was described from individuals found in Wisconsin and Massachusetts; it has now been found in six more states. In addition to those already reported, collections from the seven different states have given one hundred and fourteen individuals: Wisconsin—Buffalo Lake, at Endeavor, August 24, 1905; Buffalo Lake, at Packwaukee, September 5, 1904; Underwood's Pond, Montello, September 6, 1904; Green Lake, September 9, 1905; Lake Wingra, Madison, August 29, 1905; Peaslee's Pool, Lake Spooner, August 3, 1906. Illinois—Havana, April and August, 1895 (coll. from State Biol. Sta.). Michigan—Grand Rapids, summer of 1895 (Dr. R. H. Wolcott); Kawkawlin R., August, 1895 (Mr. J. B. Shearer). Missouri—Columbia, artificial lakes, summer of 1901 (Dr. R. H. Wolcott); Rocheport, ponds, June and July, 1904 (Dr. R. H. Wolcott). Nebraska—Bellevue, Wiley's Pond, September 4, 1897 (Dr. H. B. Ward); Omaha, summer of 1903 (Dr. R. H. Wolcott); South Bend, pond, September 1, 1897 (Dr. H. B. Ward); Springfield, Niobrara River, June 23, 1902 (Mr. J. C. Crawford). Indiana—Kosciusko county, lakes, July 31, 1903 (Dr. R. H. Wolcott). Louisiana—New Orleans, pond in Audubon Park, August and October, 1901; October, 1903, and October, 1904 (Mr. E. Foster); Lake Charles, September 12, 1906 (Mr. E. Foster); Slidell, October 19, 1901 (Mr. E. Foster).

One male was found colored rusty red instead of the usual blue green. This was from Peaslee's Pool, near Lake Spooner, Wisconsin, where other individuals having the same peculiarity have already been reported (1904).

Arrhenurus mamillanus n. sp.

Pl. x, figs. 32-34; pl. xi, fig. 35

A. mamillanus has a relatively short appendix, which narrows to a point at the end, where it bears several small transparent membranes. This character, together with the general form of the body, places the new species near *A. membranator* Thor. The anterior end of the body bows out; the large oval slightly elevated dorsal

shield shows no humps. The enclosing furrow runs far down on the appendix. The fourth epimera are very broad, and the two posterior groups are placed very close together. The narrow genital areas slightly overlap the ventral surface. The appendix is very broad at the base, cylindrical in the middle, and ends in a three-lobed platform. On each lateral scallop is a small transparent sac-like structure (A). The extreme end of the middle scallop has a blunt point (B), which a lateral view shows to be likewise a small membrane. Two other tiny membranes (C) are made out by careful search near the low humps on the dorsal surface. There are four pairs of long, fine hairs on the end of the appendix, and two pairs of very short ones on the dorsal surface. *A. mamillanus* is 1.03 mm. long and 0.62 mm. wide. The color is yellowish brown in preserved specimens.

Only one individual of the species has been found. This was collected by Mr. G. D. Nourse, July 29, 1906, at Charlestown, N. H.

Arrhenurus solifer n. sp.

Pl. xi, figs. 36-38

A. solifer resembles *A. morrisoni* Mar. in the form of the body and appendix. The body is very broad where the slightly elevated dorsal shield begins; there is a slight bulging over each eye, and one on each side between the epimera and the genital field. The dorsal furrow opens ventrally on the base of the appendix. Epimera and genital field are much the same as in the related species; the latter projects so as to be seen from the dorsal side. The appendix is narrow at the base, becomes very wide and arched in the anterior third, and then much constricted in the posterior third. Here it rounds out and is slightly scalloped. At the point where the constriction begins may be seen a small pair of elevations (A). There are four pairs of short hairs near the end, and two more pairs on the dorsal surface. The color in preserved specimens is brownish green. The entire length is 1.23 mm.; the greatest width, 0.76 mm.

Four individuals of this species were found by Mr. G. D. Nourse at Charlestown, New Hampshire, one on August 20, 1905, and three more on October 29 following.

Arrhenurus scutuliformis n. sp.

Pl. xi, figs. 39-42

A. scutuliformis male resembles *A. pseudoconicus* Piers., one individual of which has been found in Wisconsin, and the European form *A. conicus* Piers. It differs from the former, to which it is more closely related, in being larger and relatively less stout. The body is orbicular, bowed out anteriorly; the dorsal enclosed area has the same form and is well arched, the end of the furrow being on the base of the appendix. The first and second spimera are wide and have blunt outer ends. The genital wings are short and broad, slightly over-reaching the ventral surface; a few short hairs grow on the posterior margin. The appendix is slightly constricted near the center, and a lateral view shows that the dorsal surface is not uniformly arched but has two low humps, the anterior one the higher. The extreme end is much narrowed and low, with a slight indentation in the center. Just in front of the posterior constriction is a pair of small elevations with a fine hair in front of each. Four pairs of longer hairs grow from the depressed end of the appendix. The body measures 1.4 mm. in length and 0.75 mm. in width. The color of the preserved material is dull yellowish brown.

A. scutuliformis fem. is ovate, the region between the eyes much narrowed and slightly bulging; there are slight posterior lateral angles on the body. The anterior epimera resemble those of the male, being broad and very blunt. The inner borders of the fourth, however, are much rounded off. The capitulum in both sexes is long and lacks the usual central wedge-shaped incision; its typical shield-shaped form has suggested the specific name. The genital wings are long and oval, much constricted where they join the genital plates, and placed obliquely. The length of the body is 1.23 mm.; the width, 1.1 mm.

Three individuals of this species are known, all of them from the collections of Dr. R. H. Wolcott from Michigan. One male and one female were taken, August 18, 1893, at New Baltimore; and one male, in the summer of 1895, at Grand Rapids.

Arrhenurus pseudocylindratus Piers.

Pl. xvi, fig. 80

1903. *A. cylindratus* Marshall. Trans. Wis. Acad., xiv:156-157, pl. 17, fig. 8.

1904. *A. pseudocylindratus* Piersig. Zool. Cent., xi:210.

A. pseudocylindratus is not closely related to the preceding species, but it has an appendix narrowed at the end. The structures here, however, and the slightly elevated central region, are like those of Series C. The body is unusually long and the projections over the eyes are pronounced. The palpi are stout; the second joint bears several bristles, and the fifth, which is cleft, has a forked hair at its base.

This is one of the rarer Arrhenuri, but it is now known in six states. Since first reported, fourteen other individuals have been found in eleven collections, as follows: Wisconsin—Underwood's Pond, Montello, September 6, 1904; Lake Mason, Briggsville, August 16, 1905; Benoit Lake, Burnette county, August 15, 1906. Michigan—Grand Rapids, summer of 1895 (Dr. R. H. Wolcott); Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott). Indiana—Kosciusko county lakes, July 31, 1903 (Dr. R. H. Wolcott). New Hampshire—Ammonoosuc Lake, August 22, 1900 (Dr. R. H. Wolcott); Charlestown, September 17, 1905 (Mr. G. D. Nourse). Louisiana—Slidell, August 18 and October 19, 1901 (Mr. E. Foster). Wyoming—Yellowstone Park, August 8, 1890 (Prof. S. A. Forbes).

Arrhenurus capillatus n. sp.

Pl. xii, figs. 43-45

A. capillatus, with its relatively short appendix, appears to stand at the head of a line of development. The body is almost orbicular except for a moderate bulging out in the anterior region. The dorsal furrow runs over on the base of the appendix, where the ends join. The region outside of the shield is arched. The first and second epimera have moderately sharp points; the third has a narrow inner border. The genital wings are narrow, the borders indistinct, and they do not form the usual rolls at the sides. A peculiar fea-

ture, which has suggested the specific name, is the fringe of hairs on the posterior border of the area. The appendix is one of the shortest in the subgenus; it is rather stout, slightly broadest in the center, where it is moderately arched. A pair of low humps (A), close together, lie just back of the central arch, each bearing a fine hair. The posterior end is low and slightly indented; here are found four pairs of short hairs and a pair of tiny bristles on the dorsal surface. The color in preserved material is yellowish brown. The average length is 1.1 mm.; the width, 0.72 mm.

Only two individuals are known; these were collected by Mr. R. S. Gray in the outlet of Laguna de la Merced, San Francisco, California, October 15, 1905.

Arrhenurus manubriator Mar.

Pl. XII, figs. 46, 47

1903. *A. manubriator* Marshall. Trans. Wis. Acad., XVI:151-152, pls. 15-17, fig. 3.

A. manubriator is closely related to *A. capillatus;* the appendix, however, is relatively longer, and both body and appendix show a slightly greater development of humps.

A. manubriator fem. is now figured and described for the first time. The body is obovate; the anterior region projects, the posterior end shows slight side corners, between which the body bows out. The enclosed dorsal area is ovate, the posterior border slightly bent in. The ventral plates are much like those of the male, the first and second very wide at the outer ends. The most characteristic feature is the genital area; the semicircular plates closing the opening are unusually large, and the genital areas extending from them short and wide. The body has numerous hairs, which are mostly fine ones. The palpi are like those of the male. The length is 0.9 mm.; the width, 0.82 mm.

The species is one of the commonest; the localities where it has been found in the United States are here given, together with one collection from Mexico. By far the largest number were taken in Michigan. It is noticeably absent from Missouri and Nebraska, although material was examined from several different localities.

Over three hundred individuals of the two sexes were found, in twenty-two collections. Wisconsin—Lake Winnebago, at Oshkosh, August, 1897 (Dr. R. H. Wolcott); Lake Mason, Briggsville, August 16, 1905; Buffalo Lake, at Endeavor, August 24, 1905; Lake Wingra, Madison, August 1, 1904; Lake Mendota Bay, Madison, September, 1905; canal at Portage, August 24, 1905; Lake Spooner, Washburn county, August 8, 1906. Illinois—Fox Lake, September 17, 1894 (Dr. H. B. Ward). Michigan—Charlevoix, July, 1894 (Dr. R. H. Wolcott); Charlevoix, Susan Lake, August 21, 1894 (Dr. R. H. Wolcott); Black Lake, Emmett county, September 3, 1894 (Dr. R. H. Ward); Grand Rapids, summers of 1895 and 1900 (Dr. R. H. Wolcott); Saginaw Bay, 1895 (Mr. J. B. Shearer); Lake St. Clair, summer of 1893 (Dr. R. H. Wolcott). Indiana—Shoe Lake, Kosciusko county, July 31, 1903 (Dr. R. H. Wolcott). Massachusetts—Falmouth, Shiverick Pond, August 14, 1900 (Dr. R. H. Wolcott). Mexico—Guanajuato, 1900 (Mr. Alfred Dugès).

Arrhenurus marshalli Pier.

Pl. XII, figs. 48, 49

1903. *A. globator* Marshall. Trans. Wis. Acad., XIV:148-150, fig. 1.
1904. *A. marshalli* Piersig. Zool. Cent, XI:210.

This *Arrhenurus* shows an elongation of the body and a greater development of humps upon it than do the preceding species, while the end of the appendix is high and much broadened out at the end. Each palpus bears a large bunch of small bristles on the inner surface of the second joint; the fifth claw-like joint is cleft. The palpi are alike in the two sexes except that the female's is slightly larger. This has been found to hold true in all the Arrhenuri examined, and the principle is of great value in identifying the females.

The female of this species shows some variation in form, as has already been noted for the male (1903). The posterior lateral humps are often not strongly developed. It may be distinguished from other female Arrhenuri which it closely resembles by the general obovate outline of the body, the region of the eyes being narrowed; by the development of the body humps, and by the shape of the

genital areas, the inner posterior borders of which drop down abruptly from the genital lips. One individual was orange red with red legs instead of the usual blue green color. A male was also found of the same color.

A. marshalli is the commonest and most widely distributed *Arrhenurus* in this country. It is now known in ten states, over eight hundred individuals of the two sexes being found, in some eighty collections.

Wisconsin—Pools at Appleton; Buffalo Lake, Endeavor; Buffalo Lake, and Underwood's Pond, Montello; Buffalo Lake, Packwaukee; North Park lagoon, Oshkosh; Green Lake and mill-pond at Green Lake; Lake Wingra and Lake Monona, Madison; pool at McFarland; pool at Poynette; Mirror Lake, Delton; Lemonweir River, Mauston; Lake Spooner, Washburn county; Lake Mason, Briggsville; and Benoit Lake, Burnette county; during the months of the summers and falls of 1904, 1905, and 1906; Lake Winnebago, Oshkosh, August, 1897 (Dr. R. H. Wolcott). Illinois—Galesburg, September, 1895 (Prof. J. G. Needham); Havana, summers and falls of 1894, 1895, and 1896 (coll. from State Biol. Sta.). Michigan —Lakes near Grand Rapids, summers of 1895, 1896, 1898, and 1899 (Dr. R. H. Wolcott); Kawkawlin River, August, 1895 (Mr. J. B. Shearer); Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott); Black Lake, Emmett county, September 3, 1894 (Dr. R. H. Ward); New Baltimore, Lake St. Clair, August 18, 1893 (Dr. R. H. Wolcott). Missouri—Columbia, artificial lakes, summers of 1901 and 1904 (Dr. R. H. Wolcott); Rocheport, ponds, June and July, 1904 (Dr. R. H. Wolcott). Nebraska—Cherry county, ponds, June 9, 1903 (Dr. R. H. Wolcott); Ft. Robinson, pond, August 22, 1906 (Dr. R. H. Wolcott); Omaha, pond, summer, 1903 (Dr. R. H. Wolcott); Springfield, Niobrara River, June 23, 1902 (Mr. J. C. Crawford). New Hampshire—Charlestown, ponds, August and October, 1905 and 1906 (Mr. G. D. Nourse). Indiana—Eagle Lake and other lakes in Kosciusko county, July 30 and 31, 1903 (Dr. R. H. Wolcott). Louisiana—New Orleans, Audubon Park, August and October, 1901 (Mr. E. Foster). New York—La Salle, Little Niagara River, August 22, 1904 (Dr. R. H. Wolcott). New Jersey —Passaic, June 19, 1902 (Mr. E. W. Berry).

Arrhenurus megalurus Mar.

Pl. XII, figs. 50-52

1903. *A. megalurus* Marshall. Trans. Wis. Acad., XIV:150-151, pls. 14, 15, fig. 2.

A. megalurus male is closely related to *A. marshalli;* the elongation of the body, the development of the humps, and the widening and differentiation of the end of the appendix have gone still further.

The variations in the form of *A. megalurus* male, particularly in the size and sharpness of the humps in front of the eyes, in the development of the scallops at the posterior end of the appendix, and in the size and shape of the dorsal hump of the appendix, already noted (1903) in collection from Wisconsin and Massachusetts, are found in the larger amount of material now at hand. This variation does not appear to be due entirely to the age of the individuals. In collections from two localities a striking variation in color from the normal blue green was found—a variation, however, which has been found in several other species of Arrhenuri. One male from Charlestown, New Hampshire, had the markings on the body bright brick red, while all of the species (four males in all) collected from Dock's Lake, Washburn county, Wisconsin, and from a small pool near by, were entirely of this color.

A. megalurus fem., which is now known, has a striking form which easily distinguishes it from other females of the genus. The sharp bumps on the body which are so characteristic a feature of the male are found to a degree unusual in the female. The anterior part of the body projects slightly and is concave between the eyes, as in the male; and here there is also the same pair of conical projections over the eyes, sometimes longer and more abrupt than are figured. Just outside of the dorsal enclosed area, at the anterior end, are two large, stout humps, farther back than the corresponding pair in the male. Two smaller ones lie posterior to these, on the side. But the most prominent feature of the body is the unusual development of the posterior end. A pair of large, stout humps project out from the posterior lateral corners of the body. Behind these the body is usually strongly bowed out, and here are two more

pairs of conical humps, one dorsal and one ventral. All of the humps have hairs. The epimera and genital wings are almost identical with those of *A. marshalli*. *A. megalurus* female measures 0.96 mm. in length and 0.85 mm. in width. The palpi are like those of the male, and resemble those of *A. marshalli*.

The statement made earlier by the author (1903) that this female was hardly to be distinguished from *A. marshalli* female is thus shown to be inaccurate.

This mite is one of the commonest in the subgenus of the same name, being represented in fifty collections from ten different states. In all, one hundred and eighty-three individuals of the two sexes were found. The localities where collections were made are given.

Wisconsin—Lake Mason, Briggsville; Brown's Pond, near Briggsville; Buffalo Lake, at Endeavor; Buffalo Lake, at Packwaukee; Buffalo Lake and Underwood's Pond, Montello; Green Lake and mill-pond, Green Lake; Lake Wingra, Madison; Mirror Lake, Delton; Lemonweir River, Mauston; Lake Spooner, Dock's Pond and pool near Dock's Pond, Washburn county; Benoit Lake, Burnette county; various dates during June, July, August and September of the years 1904, 1905 and 1906. Illinois—Havana, October 10 and 11, 1894 (coll. from State Biol. Sta.); Fox Lake, September 17, 1894 (Dr. H. B. Ward). Michigan—West Twin Lake and Susan Lake, Charlevoix, August, 1894 (Dr. R. H. Wolcott); Intermediate Lake, Ellsworth, August 9, 1894 (Prof. C. D. Marsh); various lakes near Grand Rapids, summers 1895, 1896, 1897, 1898, and 1900 (Dr. R. H. Wolcott). Missouri—Columbia, artificial ponds, summer of 1901 (Dr. R. H. Wolcott); Rocheport, ponds, summers of 1901 and 1904 (Dr. R. H. Wolcott). Nebraska—Omaha, September 1, 1903 (Dr. R. H. Wolcott); Pilger Lake, Pilger, August 2, 1900 (Miss C. A. Stringer). Maine—Sebago Lake, August 1, 1907 (Mr. A. A. Doolittle). Louisiana—New Orleans, September 28, 1906 (Mr. E. Foster). New Hampshire—Charlestown, summers and falls of 1905 and 1906 (Mr. G. D. Nourse). Indiana—Eagle Lake (Winona Lake), and other lakes in Kosciusko county, July 30 and 31, 1903 (Dr. R. H. Wolcott). New Jersey—Passaic, April 20, 1902 (Mr. E. W. Berry).

Arrhenurus parallelatus Mar.

1903. *A. parallelatus* Marshall. Trans. Wis. Acad., XIV:154-155, pls. 16-18, fig. 6.

The position of this *Arrhenurus* is uncertain. The shape of the body is like that of some members of Series C, but the end of the appendix is not developed in the same way. A striking feature is the rounded incision at the end in which lies a tiny stalk, perhaps representing a petiole, characters which are found in the subgenus *Micrurus*.

A. parallelatus is not a common species. Described from individuals collected in Massachusetts, it is now known from three other states. Twenty-two individuals were found.

Wisconsin—Underwood's Pond, Montello, September 6, 1904; Buffalo Lake, at Packwaukee, September 5, 1904; Buffalo Lake, at Endeavor, August 24, 1905; Lake Spooner, Washburn county, August 31, 1906. Michigan—Grand Rapids, summer of 1895 (Dr. R. H. Wolcott); Les Chenaux Islands, August, 1905 (Mr. J. B. Shearer). Massachusetts—Shiverick Pond, Falmouth, August 14, 1900 (Dr. R. H. Wolcott); Cranberry Pond, Woods Hole, August 13, 1900 (Dr. R. H. Wolcott). New Hampshire—Charlestown, October 11, 1906 (Mr. G. D. Nourse).

Arrhenurus expansus n. sp.

Pl. XIII, figs. 53-55

The most striking characteristic of this species is the very broad fan-shaped posterior end of the appendix. The body, which is oval, projects slightly in the region of the eyes. On the ventral side behind the epimera there is a pair of prominent humps, so prominent that they are seen from the dorsal side also. The genital area is very small. The fourth epimera have rather sharp posterior angles. The ends of the dorsal furrow join ventrally at the base of the appendix. The body has a low hump on either side outside of the dorsal shield.

The very long appendix broadens gradually a third of the distance from the base. Just anterior to the center is a slight enlargement and a lateral view shows a small hump in this region on the

dorsal side. The broad end has prominent low rounded corners, between which it is rounded out without indentations. There are three pairs of long hairs here, with two shorter pairs on the dorsal surface and one on the ventral. The length of the body is 1.25 mm.; the width, 0.65 mm. The color is brownish in preserved specimens.

Three males of the species were obtained by Mr. E. Foster from collections in Louisiana in 1901; one was made August 11, in Audubon Park, New Orleans, and the other two at Slidell, October 19.

Arrhenurus pseudocaudatus Piers.

1904. *A. caudatus* Marshall. Wis. Acad., XIV:521-523. pl. 40, fig. 1.

1905. *A. pseudocaudatus* Piersig. Zool. Cent., XII:185.

A. pseudocaudatus appears to stand near the beginning of a line in which the long appendix of the male reaches its highest development.

This species was described from one male found in the inlet of Lake Spooner, in northwestern Wisconsin, and later unfortunately lost. No other individuals were ever found in that place, although several collections have been made. But in material from High Island Harbor, Lake Michigan, secured by Dr. R. H. Wolcott, August 18, 1894, five individuals were found wich appear to be the same species. In all details of structure there is close agreement with drawings of the type form; but measurements show that the Michigan forms are uniformly larger.

Arrhenurus prominulus n. sp.

Pl. XIII, figs. 56-60

In general shape of body and appendix and in the structures on the latter the new species appears to be closely related to *A. pseudocaudatus* Piers. The body is obovate, bulging out in the eye region. The dorsal shield follows the outline of the body. The fourth epimera are broad, somewhat rectangular, and close together. The genital area do not overlap the ventral surface. The appendix is widest in the anterior third, and here it is also thickest. Back

of this point it is constricted and bears a large double hump (A). At the base of this structure are four low humps, much like the corresponding structures in the related species. The two outer (B) have on the inner border a semicircular row of small oblong structures; the other pair, close together, are smaller rounded humps (C). The end of the appendix widens slightly and ends in four scallops, the central longest; between the latter is a very small papilla. Four pairs of short hairs are found on the sides, and one dorsal pair. The entire length of the body is 1.15 mm.; the width, 0.65 mm. The color in preserved speciments is bluish dull brown with darker markings on the dorsal side.

Female. The color and markings are the same as those of the male; the general outline of the body is obovate, with a very narrow convex region in front of the eyes. The dorsal shield, also, is very large and obovate. The body is rather flat. The epimera are much like those of the male. The shape of the genital area differs somewhat from the usual form and affords a means of distinguishing this female from other species. The semicircular plates of the genital openings are large, while the wing-shaped areas are relatively small and extend almost straight outward with slightly enlarged ends. The total length of the body is 1.13 mm.; the greatest width, 0.95 mm.

This species occurs only in collections from Forest Grove, Oregon, made by Dr. E. R. Walker. The collecting ground was Todd's Pond, a large shallow body of water filled with water plants. Several collections were made in the summer of 1905 which yielded six males and twenty females; and in the following summer there were found seven males and six females. It is interesting to note that only two other species of the genus were found, each represented by one individual only, together with one unidentified female.

Arrhenurus krameri Koen.

1895. *A. krameri* Koenike. Abh. Ver. Bremen, XIII:182, pl. 1, figs. 16-20.

1901. *A. krameri* Piersig. Das Thierreich: 85.

This species, described by Dr. F. Koenike from one male found in the Flathead River, British Columbia, near the international

boundary, has not been reported since. It is, therefore, a matter of great interest to find this *Arrhenurus* in a new locality. In collections made by Dr. E. R. Walker at Forest Grove, Oregon, in the summer of 1905, there was found one male, which by a careful comparison with Koenike's figures, appears to be *A. krameri*. *A. prominulus* stands very close to it, but does not show as great a differentiation of the end of the appendix.

Arrhenurus rectangularis n. sp.

Pl. XIV, figs. 61-63

This species is closely related to *A. krameri*, *A. prominulus*, and the following species. The characteristic form of the appendix is suggested by the specific name which was first employed by Dr. R. H. Wolcott. The body is obovate, slightly bulged out over each eye and in the region of the genital area. The dorsal shield is ovate, the enclosing furrow ending posteriorly far down on the base of the appendix. The first and second epimera have blunt anterior ends. The genital wings are rather broad and scarcely project over the body wall. The hairs on the dorsal side of the body, marking the openings of skin glands, are very long. The appendix is widest in the anterior third, where it is slightly elevated as in the related species. It ends rather abruptly with very pronounced lateral corners which project out farther than the middle region; the latter is bowed in and has a papilla in its depth. The last third of the appendix is highest, having a sharp double hump (A) with a pair of fine hairs. Posterior to it is a pair of humps (B), each one close to the body margin, with a semicircular row of oblong structures of unknown significance, similar to those of *A. prominulus*. Between these humps is a pair of smaller ones (C), on which are the openings of glands. The entire length of the body is 1.3 mm.; the greatest width, 0.68 mm. The color in preserved material is dark bronze green.

Three individuals of this species are known, all of them in the collection of Dr. R. H. Wolcott. One was found in Lake St. Clair, Michigan, August 10, 1893; the other two in Cranberry Lake, Woods Hole, Massachusetts, July 28, 1900.

Arrhenurus semicircularis Piers.

Pl. XIV, fig. 64; pl. XVII, fig. 129

1903. *A. securiformis* Marshall. Trans. Wis. Acad., XIV:152-153, pl. 18, fig. 4.

1904 *A. semicircularis* Piersig. Zool. Cent., XI:210

This species closely resembles *A. krameri* Koen. and the preceding species, but the appendix is relatively slimmer, and the end, as seen in the lateral view, is the thickest part and bears a more conspicuous united dorsal hump. The body is decidedly obovate.

The fourth leg is slender, the last two joints being long, as is characteristic of the males of the subgenus. The third, fourth and fifth joints are well supplied with swimming hairs, and the spur on the fourth is conspicuous. The palpus is stout.

A. semicircularis is seldom met with. It was first described from Massachusetts; it has since been found in three other states. Twenty-two individuals were found.

Wisconsin—Underwood's Pond, Montello, September 6, 1904; Lake Mason, Briggsville, August 16, 1905. Michigan—Grand Rapids, summer of 1895 (Dr. R. H. Wolcott). Massachusetts—Shiverick Pond, Falmouth, August 14, 1900 (Dr. R. H. Wolcott); Cranberry Pond, Woods Hole, July 28, August 13, 1900 (Dr. R. H. Wolcott). New Hampshire—Charlestown, September 17, October 1, 1905 (Mr. G. D. Nourse).

Arrhenurus longicaudatus n. sp.

Pl. XIV, figs. 65-67

The most prominent feature of this new species is the great length of the appendix, which is relatively longer than in any other species of the genus. The specific name which it has suggested was first employed by Dr. R. H. Wolcott. The conspicuously obvate body is like that of *A. semicircularis* Piers; but it is more strongly arched. The fourth epimera are very broad. The genital wings project beyond the ventral surface and are very broad. The appendix is narrowest at the base, but does not vary greatly in width throughout. The center is broadest and greatly arched. Just posterior to this is a prominent hump; at its base is a shallow furrow

in which lies a peg-like structure (A). This structure did not appear in two individuals, which were young. The end of the appendix, which is low, flares out somewhat; in the slightly indented center lies a very small papilla. Four pairs of short hairs grow from the sides. The average length of the entire body is 1.24 mm.; the width, 0.78 mm. The color of the preserved specimens is brownish orange.

Only three males of *A. longicaudatus* are known, all from New Hampshire. Two were found by Dr. Wolcott in Ammonoosuc Lake near Crawford in the White Mountains, August 22, 1900; and one by Mr. G. D. Nourse at Charlestown, July 29, 1906.

Arrhenurus cornicularis n. sp.

Pl. XIV, figs. 68-70

This species and the next, *A. apetiolata,* form an interesting group by themselves whose relationship is not clear. In this group belong also the Brazilian species *A. corniger* Koen. and *A. ludificator* Koen., and *A. uncatus* Daday from Paraguay. All are characterized by the presence of a large pointed hump on the anterior dorsal surface of the appendix like similar structures common near the base of the appendix in the subgenus *Arrhenurus.* It has been shown by Thon (1900) that these humps in forms like *A. neumani* Piers. cover large accessory genital glands which in the subgenus *Megalurus* are accommodated in the prolonged appendix. It would be an interesting subject for future investigation to determine the disposition of these glands in this group of New World species which have both the long appendix and the large humps.

A. cornicularis is a small species, the entire length being 0.93 mm. and the greatest width 0.59 mm. The general form of the body is almost orbicular with slight projections in front of the eyes. Epimera and genital area are of the usual form; the anterior plates do not have the sharp points of the related species. The appendix is broad at the base and of nearly the same width throughout, being relatively shorter and stouter than in *A. apetiolata.* The sharp abrupt projection (A) already referred to is just anterior to the center, and here the body is slightly widened. The extreme end has a slight indentation and bears two pairs of little knobs

(B, C) on the dorsal surface; at the base of the former is a little point (D). The spur on the fourth leg is small. The color of *A. cornicularis* in preserved specimens is dull bronze green.

Only two individuals are known. These were collected by Dr. R. H. Wolcott at Grand Rapids, Michigan, in the summer of 1895.

Arrhenurus apetiolata Piers.

Pl. xv, fig. 11

1903. *A. corniger* Marshall. Trans. Wis. Acad., xiv:155-156, pl. 15, fig. 7.

1904. *A. apetiolata* Piersig. Zool. Cent., xi:210.

When the species was first described (1903), the female was unknown. It has since been found and a description is now possible.

A. apetiolata fem. very closely resembles *A. marshalli* fem., so closely indeed that the two forms are separated only with great difficulty. The body is ovate, a trifle broader relatively at the posterior end. The small humps above the eyes, at the posterior corners and near the dorsal line are not as prominent as in the related form; and the body at the posterior end is simply bowed out, with no trace of the small elevations which are here often rather well developed in *A. marshalli.* The epimera are nearly the same in form, but the second pair ends in sharper points in *A. apetiolata.* The point of special difference is in the form of the genital region. The wing-shaped areas are relatively short; the upper margin slopes out and back; and most important of all for purposes of identification, it will be noticed that the inner posterior margin runs obliquely out and back, not straight back, as in *A. marshalli. A. apetiolata* fem. measures 0.93 mm. in length and 0.88 mm. in width.

A. apetiolata is fairly abundant and has been found in thirty-two collections from six states. The total number of individuals of both sexes found was over three hundred and fifty. The localities are here given:

Wisconsin—Buffalo Lake at Endeavor, August 24, 1905; Underwood's Pond, Montello, September 6, 1904; Green Lake and mill-pond, September 9, 1905; Lake Spooner, Washburn county, August 6, 18, 1906; Benoit Lake, Burnette county, August 15, 1906.

Illinois—Havana, summers and falls of 1894 and 1895 (coll. from State Biol. Sta.). Michigan—Grand Rapids, September 30, 1895 (Dr. R. H. Wolcott). Missouri—Columbia, artificial lakes, summers of 1901 and 1904 (Dr. R. H. Wolcott); Rocheport, ponds, summer of 1904 (Dr. R. H. Wolcott). Nebraska—Omaha, ponds, September 1, 1903 (Dr. R. H. Wolcott); Pilger Lake, Pilger, August 2, 1900 (Miss C. E. Stringer); Springfield, June 23, 1902 (Mr. J. C. Crawford). Louisiana—New Orleans, Audubon Park, August 11, 1901 (Mr. E. Foster); Slidell, October 19, 1901 (Mr. E. Foster); Lake Charles, September 12, 1906 (Mr. E. Foster).

Subgenus Arrhenurus

In this division of the genus there is found the greatest development as seen in the elaborate structures upon the appendix, although the latter is not as long as it is in the preceding subgenus. The petiole is always a conspicuous feature; it is usually somewhat club-shaped and grows from the middle of the ventral surface of the appendix, presenting a great variety of form. The petiole is believed to be a copulatory organ. At its base on the dorsal side is usually found a transparent plate of chitin called the "hyaline appendage." A pair of curved bristles usually stand on either side of the appendix. The fourth leg is stouter than in the subgenus *Megalurus* and its spur is well developed.

Within the subgenus there are three rather pronounced types. In one, designated here as Series A, the appendix is very short and narrow, the posterior lateral angles are small, there are no conspicuous humps upon the body, and the hyaline appendage is small or wanting. In Series B the appendix is well developed with conspicuous posterior lateral projections directed outward; near its base are found a pair of sickle-shaped elevations within the dorsal furrow. In Series C the appendix tends to elongate, while near its base lies a pair of large conical bumps.

The new species to be described are grouped as follows:

Series A	Series B	Series C
A. trifoliatus n. sp.	*A. pistillatus* n. sp.	*A. amplus* n. sp.
A. planus n. sp.	*A. compactilis*, n. sp.	*A. magnicaudatus* n. sp.
A. angustocaudatus n. sp.	*A. falcicornis* n. sp.	*A. superior* n. sp.
A. dentipetiolatus n. sp.	*A. laticornis* n. sp.	*A. americanus* n. sp.
A. reflexus n. sp.		*A. major* n. var.
A. wolcotti n. sp.		*A. flabellifer* n. sp.
		A. fissicornis n. sp.

Arrhenurus trifoliatus n. sp.

Pl. xv, figs. 72-74

This *Arrhenurus* does not conform closely to the usual structure of the subgenus; in some of its characters it shows a more primitive condition than do any of the following species. The body is oval, strongly arched in the center, with no pronounced humps. There is a bulging out in front of each eye and in the posterior lateral region. The dorsal enclosed area is oblong and slightly constricted near the center; the extremities of the furrow end blindly on the dorsal side of the base of the appendix, reminding one of the condition found in the subgenus *Truncaturus*. The last two groups of epimera are very close together. The appendix is narrow, short and low. The posterior lateral regions are simply rounded. The petiole is very broad at the base, simply a continuation of the appendix; it narrows rapidly to end in a trifoliate piece. A lateral view shows that it bends sharply to the ventral side. No hyaline appendage is present. There are an unusual number of hairs at the end, five pairs in all, and one pair on the dorsal side. The length of the entire body is 1.02 mm.; the width, 0.74 mm. The color is dull green.

Five individuals of the species are known from the following localities: Illinois—Havana, April 3, 1895 (coll. from Ill State Biol. Sta.). Nebraska—Wayne, September 8, 1899 (Miss C. E. Stringer). Missouri—Rocheport, July 24, 1904 (Dr. R. H. Wolcott). Louisiana—Audubon Park, New Orleans, August 11, 1901 (Mr. E. Foster).

Arrhenurus planus n. sp.

Pl. xvi, figs. 75, 76

This species is closely related to the European form, *A. papillator* (Müll.); it is smaller, however, and shows clearly some differences in detail. The appendix and its structure are not well developed and the body is low and flat; thus it stands among the lowest of the group. The body is almost orbicular except for the bulging at the anterior end. The dorsal furrow encloses a very large oval space, and its ends disappear dorsally at the base of the appendix

as they do in the preceding species. The genital regions are unusually small, the wing-shaped areas ending far short of the edge of the body. The fourth epimera are broad. The appendix is very short and low; but the posterior lateral angles are well developed. The petiole (A) is likewise very small; it is almost hidden by the overgrowth of the dorsal side of the body. In form it is like the letter Y inverted; on either side of it is a stiff hair, but these are not bent to form "Krummerborsten." There are also four other pairs of hairs. No trace of a hyaline appendage was found. The entire length of the mite is 1.06 mm. and the width is 0.94 mm. The preserved specimens were strongly tinged with magenta.

Four males of the species were found by Mr. G. D. Nourse at Springfield, Vermont, May 21, 1906; and five others at Charlestown, New Hampshire, in the spring of 1907.

Arrhenurus angustocaudatus n. sp.

Pl. xvi, figs. 77-79

The body is stout and broad with very pronounced outstanding posterior lateral regions. There are two projections in each eye region. The dorsal enclosed area rises back of the center in two conspicuous cones. The genital wing-shaped areas have an unusual form; they are broad when they join the genital plates, then bend rather sharply to run obliquely down and out to the body's edge which they overlap. The appendix is short and conspicuously narrow. It has well developed posterior lateral angles, each bearing two hairs. Dorsally near the end are two pairs of little elevations, the middle ones each with a stiff hair; on the ventral side are two more pairs, each bearing a hair. The hyaline appendage (A) is very broad and narrow. The petiole is somewhat peg-shaped; it has a central thickened piece (B) lying in a trough formed by the rolled-up sides (C). On either side is a stiff curved hair. The length of the entire body is 1.3 mm., and the width, 1.1 mm. The color is dull sage green.

Thirteen males of this species were collected by Professor S. A. Forbes in a weedy pond near Baronett's Bridge in Yellowstone National Park, August 30, 1891.

Arrhenurus dentipetiolatus n. sp.

Pl. XVI, fig. 1; pl. XVII, figs. 82, 83

This rare *Arrhenurus* has a stout body with very broad outstanding posterior lateral regions like the preceding species. There are two projections of the body in the region of each eye, while the center on each side shows a low cone. The fourth epimera are very wide. The genital wings are large; this region projects strongly over the dorsal side. The short stout appendix has rather well developed posterior lateral angles; each bears two hairs. Between them the dorsal region grows over the ventral to form a slightly projecting band (A), on the edge of which is a thin transparent strip which appears to represent the hyaline appendage (B). The petiole projects considerably beyond the body; it consists of a stout cylindrical heavy piece with a transparent conical tooth-like structure (C) on the end. On each side near the middle of the petiole there grows out a small curved bristle. There are two pairs of small humps near the base of the petiole, one dorsal, and a larger ventral pair, each bearing a hair. The entire length of the body is 1.24 mm.; the width, 1.03 mm. The preserving fluid has destroyed the color.

The species is known by two individuals collected by Dr. R. H. Wolcott in Colorado, November 16, 1901, one in a pond on Rush Creek, east of Laird, the other in a pool by Olive Creek, east of Wray.

Arrhenurus reflexus n. sp.

Pl. XVII, figs. 84-86

The body is stout, thick, somewhat circular in outline, widest in the anterior half. There is a slight bulging out in front of each eye. The posterior part of the body is very well filled out on the ventral side, so much so that this region with the ends of the narrow genital wings (A) shows noticeably in a dorsal view. The dorsal furrow runs over on the lateral angles of the appendix. In the posterior part of the enclosed dorsal area are two small but very abrupt circular humps (B) each with a hair. Back of each is a small, sharp, curved tooth-like structure (C). The third epimera are narrow, the fourth very wide; near the attachments of

the fourth legs the latter bear patches of short bristles. The appendix is very short; it has rounded posterior lateral angles each bearing two hairs. There is a pair of small elevations on the ventral side, each bearing a long hair. The petiole is very well developed. At its base are two little projections with a pair of long straight hairs. The stout central part of the petiole curves slightly upward; toward the end it has a transparent corner piece on each side (D). Down through the center on the dorsal face runs a long transparent spoon-shaped structure (E) grooved in the center and reflexed at the end. Two short forward curving hairs extend out from the central part near the end. The entire length of the body is 1.09 mm.; the width, 0.77 mm. The color is blue green.

Six males of this species are known. One occurred in a collection from the mill-pond at the village of Big Spring, Adams county, Wisconsin, August 17, 1905; the others were collected by Mr. G. D. Nourse, one at Springfield, Vermont, May 21, 1906, and four at Charlestown, New Hampshire, July 29 and August 20, 1905.

Arrhenurus wolcotti n. sp.

Pl. XVII, fig. 87; pl. XVIII, figs. 88, 89

This species closely resembles *A. berolinensis* Protz found in Germany. It is readily known by its very broad body and very long, large and peculiarly formed petiole. The body form is like that of *A. dentipetiolatus,* with two projections in each eye region, very broad rounded-out posterior parts, and an arched central region. The enclosed dorsal area is elevated; just anterior to the place where the appendix joins the body there are slight indications of a pair of humps. The genital wings reach barely to the body edge. The short broad appendix has rounded projecting lateral angles. The petiole projects far beyond the appendix. The anterior half is stout and heavy, ending on each side in a scallop bearing a curved bristle. Over its dorsal face and extending beyond it is a thin complex structure ending in two divergent prongs (B). Through the center runs an elongated bladder-like piece, broad at the end (A). The two very characteristic structures (B) appearing like prongs in face views are seen to be irregular vertical plate-like pieces when viewed laterally; they are attached in the ventral

region to a thicker central piece. In these details the new species differs from *A. berolinensis* Protz. The hyaline appendage is broad but short; it is reported as entirely absent in the related form. There are two small humps anterior to its place of attachment; and on the ventral side are seen the usual pair of larger humps. In all there are four pair of hairs extending beyond the body. The entire length of the body including the petiole is 1.13 mm.; the greatest width, 0.85 mm. The color is dull green.

Three individuals were found by Dr. R. H. Wolcott, in whose honor the species is named; two came from a pond on Rush Creek, east of Laird, Colorado, November 16, 1901; and one from a pond at Glen, Cherry county, Nebraska, August 25, 1906.

Arrhenurus pistillatus n. sp.

Pl. XVIII, figs. 90-92

In this species and the three following there is close resemblance in the form of the body and development of the appendix, a noteworthy feature being the sickle-shaped dorsal humps. The character of the petiole will most readily separate the species. In this group *A. pistillatus* is the simplest, as it is the smallest. The broadly oval body is slightly bulged out over each eye. The dorsal enclosed area, constricted at the anterior end, is strongly convex and bears posteriorly the pair of sickel-shaped elevations, their points directed forward. Outside of this area, in the center of the body, there is a slight elevation on each side. Epimera are of the usual form. The genital fields are narrow, their outer ends showing like bunches on the side of the dorsal view. The appendix is well developed but the posterior lateral angles are not conspicuous. Two pairs of small humps lie at the base of the appendix on the dorsal side as in the related species; the anterior bear two long hairs, the posterior are pointed. On the ventral side are two larger, low rounded humps, each with two long hairs. The pestle-shaped petiole has on the end, dorsally, a little rounded bladder (A), very conspicuous in a lateral view; two elongated bladders (B) are attached on either side of the center ventrally. The curved bristles at the side of the petiole arise from little bunches. The hyaline appendage is

large and narrows outward. The length of the entire body is 1.0 mm. and the width is 0.75 mm. The color is dull blue green.

Only one individual of the species is known; this was found in material collected by Mr. R. S. Gray from a pool in an old quarry in Alameda county, California, December 10, 1905.

Arrhenurus compactilis n. sp.

Pl. xviii, figs. 93-95

A. compactilis resembles *A. compactus* Piers. as well as the species with which it is here grouped. The body is broadly oval, slightly projecting over each eye. The enclosed dorsal area is small. At the point where it narrows into the appendix there stand two small sickle-shaped humps like those of *A. pistillatus*. The genital area has the usual elongated form, and the body here is wider ventrally than dorsally. The fourth epimera are broad, and the posterior inner border of each is rounded in. The appendix has well developed posterior lateral angles which turn strongly outward. The most characteristic feature of the species, and the one by which it is most easily recognized, is the petiole. It has the usual pestle shape, but it bears on the dorsal surface a bladder-like structure shaped like a leaf (A); this is also a prominent structure in a lateral view. The hyaline appendage is wide and narrows to its posterior border. There are the same humps at its base as in *A. pistillatus:* the ventral pair are large, each with a long hair; the dorsal ones are small, the anterior pair bearing each a long hair on a papilla, while the posterior have sharp points directed inward. The entire length of the body is 1.12 mm.; the width, 0.9 mm. The color is the usual blue green. *A. compactilis* is one of the rarer species; but fifteen males are known, all but two of which were taken in Wisconsin.

Wisconsin—Oshkosh, inlet of Lake Winnebago, August 1897 (Dr. R. H. Wolcott); Fond du Lac, river shallows, September 7, 1905; Green Lake, mill-pond, September 9, 1905; Lake Spooner, Washburn county, August, 1906. New Hampshire—Charlestown, September 17, 1905, October 11, 1906 (Mr. G. D. Nourse).

Arrhenurus falcicornis n. sp.

Pl. XIX, figs. 96-98

This species resembles *A. tetracyphus* Piers. and the others in this group. The body is very stout, the general outline oval. It bulges out near the end where the appendix joins it; and it is still broad up to the anterior third, when it narrows abruptly to bulge out over each eye. The ventral part is unusually broad where the appendix joins the body, so that this region seems to project beyond the dorsal side. At the point when the enclosed dorsal area narrows to run over onto the appendix, there are found a pair of sickle-shaped humps as in the related species. Except at this point the body is most elevated near the anterior border of the dorsal line. The fourth epimera are very broad and the inner posterior borders are strongly rounded in. The genital area is narrow and each wing-shaped piece runs out to the body edge. The appendix has very pronounced posterior lateral angles, directed out. Between them and extending beyond them is the well developed petiole with the hyaline appendage (A) at the base. The latter is wide and its posterior corners are acute. The petiole, of the usual pestle shape, has three very characteristic bladder-like structures on it. In the center on its dorsal side is a little appendage somewhat vase-shaped as seen from above (C), the base having two little points. On the ventral side of the petiole are two little elongated bladders (B) attached on either side of the center and projecting beyond it only at the end. Sometimes these projecting ends appear dorsally as little points. At the base of the petiole are the small humps found in other males of this group. The pair on the ventral side are rather stout and blunt. Two other pairs of tiny elevations are situated on the dorsal side; the posterior pair have sharp points directed inward, the anterior bear small hairs.

A. falcicornis is a large mite: the entire length is 1.33 mm.; the width, 1.02 mm. The color is the usual dull blue green. It is not common, only twelve individuals being known, all but two of which occurred in collections from central Wisconsin.

Wisconsin—Goose Pond, near Jorden Lake, Adams county, summer of 1894; Mirror Lake, Delton, August 21, 1905; Green

Lake, and mill-pond, September 9, 1905; Lemonweir River, shallows, Mauston, September 3, 1906. Indiana—Eagle Lake (Winona Lake), July 30, 1903 (Dr. R. H. Wolcott).

Arrhenurus laticornis n. sp.

Pl. XIX, figs. 99-101

A. laticornis closely resembles *A. falcicornis* but is smaller. The body is more nearly oval and both body and appendix are relatively longer, while the structure of the appendix, particularly the petiole, differs in the two species. The body inside of the dorsal line is arched. The sickle-shaped humps, so conspicuous a feature of the lateral aspect in all males of the group, are not as well developed as in *A. falcicornis*. The fourth epimera are broad but not as much rounded in on the posterior border as in the related species. The region of the genital area is broader on the ventral side than on the dorsal, causing a bulging out over the side walls as in the related species. There is the same development of humps and hairs on the appendix, but the ventral pair of humps at the base of the petiole are greatly enlarged in *A. laticornis*. The lateral posterior processes of the appendix are rather more conspicuous. The petiole, pestle-shaped, has a little bladder-like structure (A) on its dorsal face which is uniformly broad and deeply notched. The entire length of the body is 1.06 mm.; the width, 0.8 mm. The color is the usual blue green.

Sixty-four males of this species were found as follows: Wisconsin—Mirror Lake, Delton, August 21, 1905. Illinois—Havana, August, September, 1894 and 1895 (coll. from Ill. State Biol. Sta.); Galesburg, fall of 1896 (Dr. R. H. Wolcott). Missouri—Columbia, artificial ponds, summer of 1901 (Dr. R. H. Wolcott); Rocheport, Roby's pond, summer of 1904 (Dr. R. H. Wolcott).

Arrhenurus amplus n. sp.

Pl. XX, figs. 102-105

This mite, although very large, has a somewhat simpler structure than the following species in the same group. In all of them the posterior lateral angles of the appendix are well developed and the petioles are of elaborate structure. In outline *A. amplus* is

ovate with a slight double bulge over each eye. The dorsal enclosed area on the body is nearly circular; a lateral view shows this region arched prominently but there are no humps where the appendix joins. The ventral side of the body in the region of the genital area projects strongly beyond the dorsal; the genital wings are narrow and reach barely to the body edge. The appendix has nearly the same width throughout; the well developed posterior corners flare out slightly. The hyaline appendage (A) is very small, merely a scallop over the center of the base of the petiole. The petiole is very large; it has a heavy, somewhat Y-shaped median ventral piece. Thin side pieces roll up dorsally toward the center. Ventrally on either side of the base of the petiole are two well developed humps; dorsally there is a small pair, all provided with hairs. A large curved hair stands on each side of the petiole. The palpi are stout; the fourth segment is long, and the second bears several bristles. The spur on the last leg has a bunch of very long hairs. The color of this mite is blue green tinged with brick red. The entire length is 1.5 mm.; the width, 1.1 mm.

Female.—The outline is ovate with slight posterior corners. The dorsal enclosed area is nearly circular. The epimera resemble those of the male, the first and second having rather blunt points, the fourth being moderately wide. The size and form of the genital wings will distinguish this species; they are moderately long, wide, slightly enlarged at the outer ends; the inner borders are wide and rounded out to fit around the genital plates, which, however, they do not appear to touch. The inner posterior borders drop considerably below the plates. The entire length of this female is 1.83 mm.; the width, 1.57 mm.

This species is known in thirty-one individuals, fourteen of which are males. All of them were found in five collections made at Charlestown, New Hampshire, by Mr. G. D. Nourse, from July to October in 1905 and 1906.

Arrhenurus magnicaudatus n. sp.

Pl. xx, figs. 106-108

This species is easily recognized by its great size, the large broad appendix, and the form of the petiole. The body has nearly

the same width throughout, bulging out over each eye. The dorsal enclosed area is small upon the body; the furrow runs along the sides of the appendix dorsally to end finally on the ventral side of the projecting angles. Within this area at the base of the appendix is a big elevation rising abruptly to a broad blunt apex and sloping gradually back to the end of the appendix, forming the greatest elevation of the body. Near the anterior end of the enclosed dorsal area the body rises on each side to a low cone. The genital areas are small, not reaching the edge of the body. The fourth epimera are large and the two posterior groups are close together. The appendix takes up about one-third of the length of the body and it likewise is of almost uniform width. At the posterior end it broadens out a little and here are two well developed posterior lateral angles. The petiole has a heavy wrench-shaped piece on the ventral side; thinner side pieces roll in dorsally to enclose a space at the bottom of which lies a little thickened ridge. A slightly curved bristle lies on either side of the petiole. The hyaline appendage (A) is small; it is merely a narrow border to a scallop at the base of the petiole. There are two pairs of small humps just in front of the hyaline appendage, and a large pair on the ventral side in the same region bearing each a long hair. The average length of the body is 1.64 mm.; the width, 0.10 mm. The color is the usual dull blue green.

Seventeen individuals were present in collections from three different states as follows: Wisconsin—Goose Pond, near Jorden Lake, Adams county, summer of 1894; Green Lake and millpond, September 9, 1905; Lake Mason, near Briggsville, August 16, 1905; Lake Spooner, Washburn county, August 18, 1906. Michigan—Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott); Grand Rapids, July 8, 1899 (Dr. R. H. Wolcott). New Hampshire—Charlestown, September 17, October 1, 1905 (Mr. G. D. Nourse).

Arrhenurus superior n. sp.

Pl. xx, figs. 109-111

This *Arrhenurus,* the largest member of the genus thus far reported, bears a close resemblance to *A. magnicaudatus,* from

which it differs most conspicuously in the shape of the big dorsal hump and in the structure of the petiole. The form of the body is nearly identical; the lateral view shows, however, some differences. The body is arched on each side near the beginning of the dorsal enclosed area, but not as abruptly as in the related form. The large hump at the base of the appendix is uniformly rounded. The narrow genital area reaches just to the body edge. The posterior lateral angles of the appendix are rather more pronounced, while the three pairs of small humps near the base of the petiole, two dorsal and one ventral, are not as conspicuous. The petioles are distinctly different in side view. Surface views show that the ventral heavy wrench-shaped piece has attached to it two large thin extensions along its length. The hyaline appendage (A) is the same shape in both forms, but is larger in *A. superior.* This mite measures about 2.06 mm. in length and 1.2 mm. in width, with some variation. The blue green color is strongly tinged with brick red. Six individuals were found in three collections, in two of which *A. magnicaudatus* also occurred.

Wisconsin—Lake Mason, near Briggsville, August 16, 1905. Michigan—Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott); Saginaw Bay, August, 1895 (Mr. J. B. Shearer).

Arrhenurus flabellifer n. sp.

Pl. xxii, figs. 122-124

In general form *A. flabellifer* resembles the two following species but is readily distinguished from them by the large size and unusual form of the petiole. The oval body with a projection over each eye is of the usual type in this group of the subgenus. The dorsal enclosed area is depressed, the body on either side rising to a low hump. The fourth epimera are very wide, the posterior angles slight. The genital wings project over on the sides of the body and the posterior border bears several hairs. At the point where the body and appendix join is a pair of well developed conical humps as in related species. The moderately long appendix has well developed outstanding side corners, each with the customary two hairs. There are the usual three pairs of small humps at the base of the petiole; the ventral pair are rather large. The hyaline

appendage is very narrow and can easily escape attention. The petiole is very broad at the end; dorsally the sides appear to roll in toward the center; through the middle is developed a thicker piece (A), ventral and slightly projecting. The entire length of the body is 1.05 mm.; the width, 0.73 mm. The color is the usual dull blue green.

Seventeen individuals were found in collections from three states as follows: Wisconsin—Buffalo Lake at Packwaukee, September 5, 1904; Buffalo Lake at Endeavor, August 24, 1905; Green Lake and mill-pond, September 9, 1905. Illinois—Havana, August 14, 1894 (coll. from Ill. State Biol. Sta.). Missouri—Columbia, summer of 1901 (Dr. R. H. Wolcott).

Arrhenurus americanus n. sp.

Pl. xxi, figs. 112-117

A. americanus resembles several European members of the genus, particularly *A. cuspidifer* Piers. The ovate body is slightly bulged out over each eye. The dorsal enclosed area is depressed, the sides of the body on either side rising to a low cone. The furrow runs far along on the dorsal side to end on the corners of the appendix. The epimera are of the usual form, the fourth being much the widest, its posterior inner border much rounded in. The genital wings are narrow and run up on the sides of the body. At the base of the appendix lies a pair of large pointed humps directed forward, each with a hair; these structures are slightly smaller than in *A. flabellifer*. The long appendix is widest at the end where it has very pronounced lateral angles. On the dorsal side near the end are the two pairs of small humps so often found in the Arrhenuri; the anterior pair are rounded and bear each a hair, while the posterior have points directed inward. On the ventral side of the appendix is likewise the customary larger pair of humps each with a long hair. The petiole is pestle-shaped and rather simple. The hyaline appendage is large and almost rectangular. A curved bristle lies on each side of the petiole with a long straight hair outside. The entire length of the body is 0.92 mm.; the width, 0.64 mm. The color is greenish, usually strongly tinged with dull red.

The palpi are stout. The second joint has several large bristles; the claw-like fifth is cleft. The fourth leg is rather stout, as is true of other species of the short-tailed Arrhenuri. The fourth joint much exceeds the others in length and its spur is highly developed; the last two joints are conspicuously short.

Female. The body is broadly ovate and shows rather pronounced posterior lateral angles. It is distinguished from other females of the genus chiefly by the shape of the fourth epimera and of the genital area. The former are very narrow on the inner border; and the genital wings, which are close to the last plates, are very long, of almost uniform width throughout, and slope obliquely out from the genital plates. The length of the body is 1.12 mm.; the greatest width, 1.0 mm.

This is the second most widely distributed and abundant species present in the collections; over four hundred and fifty individuals were found in some fifty collections from six different states. By far the largest single collection was from North Park Lagoon, a small pond connected with Lake Winnebago at Oshkosh, Wisconsin, where ninety-two males and one hundred and one females were found, this number comprising the entire collection of adults except one. No representatives of the species were found in the numerous collections from Missouri.

Wisconsin—Buffalo Lake at Montello; Buffalo Lake at Packwaukee; Buffalo Lake at Endeavor; North Park Lagoon, Oshkosh; Fox River shallows, Appleton; Fox River shallows, Kimberly; Green Lake and mill-pond at Green Lake; Lake Wingra and Yahara River, Madison; pool near McFarland; Lemonweir River, Mauston; Lake Spooner, Washburn county; Mirror Lake, Delton; summers and falls, 1904, 1905, and 1906. Illinois—Havana, August, September, and October, 1894 and 1895 (coll. from Ill. State Biol. Sta.). Michigan—Grand Rapids, summer of 1895 (Dr. R. H. Wolcott); Intermediate Lake, Ellsworth, August 9, 1894 (Dr. C. D. Marsh); Kawkawlin River, August, 1895 (Mr. J. B. Shearer); 26 Lake, Charlevoix, August 6, 1894 (Dr. R. H. Wolcott); Susan Lake, Charlevoix, August 21, 1894 (Dr. R. H. Wolcott); Saginaw Bay, August, 1895 (Mr. J. B. Shearer); Les Chenaux Islands, August, 1895 (Mr. J. B. Shearer). Nebraska—Omaha, September 1,

1903 (Dr. R. H. Wolcott); Omaha, Child's Point, June 6, 1903 (Mr. A. S. Pearse); Hackberry Lake, Cherry county, June, 1902 (Dr. R. H. Wolcott); Pilger Lake, Pilger, August 2, 1900 (Miss C. E. Stringer); Linwood, August, 1898 (Mr. O. D. Noble); Wayne, August 2, 1899 (Miss C. E. Stringer); St. Michael, October 28, 1899 (Dr. R. H. Wolcott); South Bend, September 1, 1897 (Dr. H. B. Ward); South Bend, November 3, 1894 (Dr. R. H. Wolcott); Niobrara River, Springfield, June 29, 1902 (Mr. J. C. Crawford). New Hampshire—Charlestown, August 12, 1906 (Mr. G. D. Nourse). New York—Little Niagara River, La Salle, August 22, 1904 (Dr. R. H. Wolcott).

Arrhenurus americanus var. *major* n. var.

Pl. xxi, figs. 118-120; pl. xxii, fig. 121

In collections containing *A. americanus* male there were usually found also a smaller number of individuals very closely resembling them in structure but conspicuously larger. Ninety-seven of such males were found. In a few cases more of the larger forms occurred than of the smaller; and in some cases, even, the larger form predominated, while in the Missouri collections only the larger form was found. These larger individuals measure 1.12 mm. in length and 0.75 mm. in width, and they are blue green without the reddish tinge.

A careful examination of the two forms shows several differences in structure. The middle region of the body is not quite so elevated; the double hump at the base of the appendix is lower and blunter than in the larger form. On the ventral side of the appendix the small rounded humps near the base of the petiole are not present. But the most striking differences, aside from size, are in the hyaline appendage and the petiole. The former is conspicuously narrower on the posterior border than at the base; the petiole has the same shape in both forms, but the larger has on the dorsal face a bladder-like structure cleft at the top, projecting above and beyond the end. (Compare figs. 113 and 114 with figs. 119 and 120.)

Examination of over two hundred males of *A. americanus* shows a very great uniformity of structure. But about one-third

of the larger form showed a hyaline appendage like that of the smaller form, that is, sharply rectangular; while a few individuals had not only this peculiarity but also a corresponding petiole, without the bladder-like ending. Moreover, eleven individuals differed from the rest in that the lateral projecting corners at the end of the appendix were less developed and more strongly directed outward. And besides, the hyaline appendage of these individuals was like that of *A. americanus,* while the petiole was like that of the larger form. (See fig. 118.)

It would seem, therefore, that we have here a variable and yet a distinct type from that of *A. americanus.* But as it agrees in so many ways with the latter, and is found so often associated with it, it has seemed proper to regard it as a variety of the smaller, commoner, and less variable species.

Wisconsin—Underwood's Pond at Montello; Buffalo Lake at Endeavor; Fox River shallows at Appleton; Fox River shallows at Kimberly; Green Lake; Lake Mendota, Madison; pool near McFarland; Lemonweir River at Mauston; Lake Spooner, Washburn county; Goose Pond near Jorden Lake, Adams county; August, September, and October, 1894, 1904, 1905, and 1906; Lake Winnebago, Oshkosh, August 31, 1897 (Dr. R. H. Wolcott). Illinois—Havana, August and September, 1894 and 1895 (coll. from State Biol. Sta.). Michigan—Grand Rapids, summer of 1895 (Dr. R. H. Wolcott); Grand River at Grand Rapids, July 27, 1898 (Dr. R. H. Wolcott); Kawkawlin River, August, 1895 (Mr. J. B. Shearer); Reed's Lake, Grand Rapids, June 28, 1899 (Dr. R. H. Wolcott); Saginaw Bay, August, 1895 (Mr. J. B. Shearer). Missouri—Columbia, artificial lakes, summers of 1901 and 1904 (Dr. R. H. Wolcott); Rocheport, ponds, summer of 1904 (Dr. R. H. Wolcott). Nebraska—Omaha, September 3, 1903 (Dr. R. H. Wolcott); Wayne, August 22, 1899 (Miss C. E. Stringer); South Bend, Fish Hatchery, September 1, 1897 (Dr. H. B. Ward); Bellevue, Wiley's Pond, September 5, 1897 (Dr. H. B. Ward); Niobrara River, Springfield, June 23, 1902 (Mr. J. C. Crawford). New Hampshire—Charlestown, summers and falls, 1905 and 1906 (Mr. G. D. Nourse). Indiana—Eagle Lake (Lake Winona), July 30, 1903 (Dr. R. H. Wolcott). Louisiana—Slidell, October 19, 1901 (Mr. E. Foster).

Arrhenurus fissicornis n. sp.

Pl. xxii, figs. 125-127

A. fissicornis is a large and rare form whose relationship is uncertain. It is easily recognizable by the big, elaborately developed petiole. The body is almost circular in outline, with only a slight projection over each eye. At the point where the appendix joins it, there is a large conical hump on each side having a double point (A). The fourth epimera are very wide. The genital wing-shaped areas are rather narrow but long, and curve up onto the projecting ventral side in an unusual manner (B). The appendix is stout and the end, where projecting lateral angles are well developed, almost as wide as the body. The hyaline appendage (C) is very small, not even covering the base of the petiole. The petiole is large and stout, somewhat resembling that of *A. reflexus*. The anterior and middle portions are covered with a heavy integument with pore-openings as is the body; a small curved hair on either side marks the limit. The end has two lateral rounded transparent pieces (D). Through the center dorsally extends a spoon-shaped piece (E) with four tiny bristles at the end. At the base of the petiole on the ventral side is a pair of rather large humps, each with a long bristle. Another stout bristle stands on either side of the petiole, but these are scarcely bent, as are the hairs usually found in the same position in other species of the subgenus. The spur of the fourth segment of the last leg is well developed and the distal end of the fifth is produced into two chitinous prongs. The length of the body is 1.27 mm.; the width, 0.86 mm. The color, as usual, is dull blue green.

But two individuals of the species are known, both from the collections of Dr. R. H. Wolcott: one came from Reed's Lake, Grand Rapids, Michigan, July 23, 1898; the other from Eagle Lake (Winona Lake), Indiana, July 30, 1903.

III

ACKNOWLEDGMENTS

To Dr. Robert H. Wolcott, the American hydrachnologist, the author is deeply indebted for the use of his private library and col-

lections and for continued advice and assistance. Doctor Henry B. Ward, head of the Department of Zoology of the University of Nebraska, by his interest and aid, has made this study of the American Arrhenuri possible. The author wishes to express most sincere thanks to both.

IV

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PLATE VII

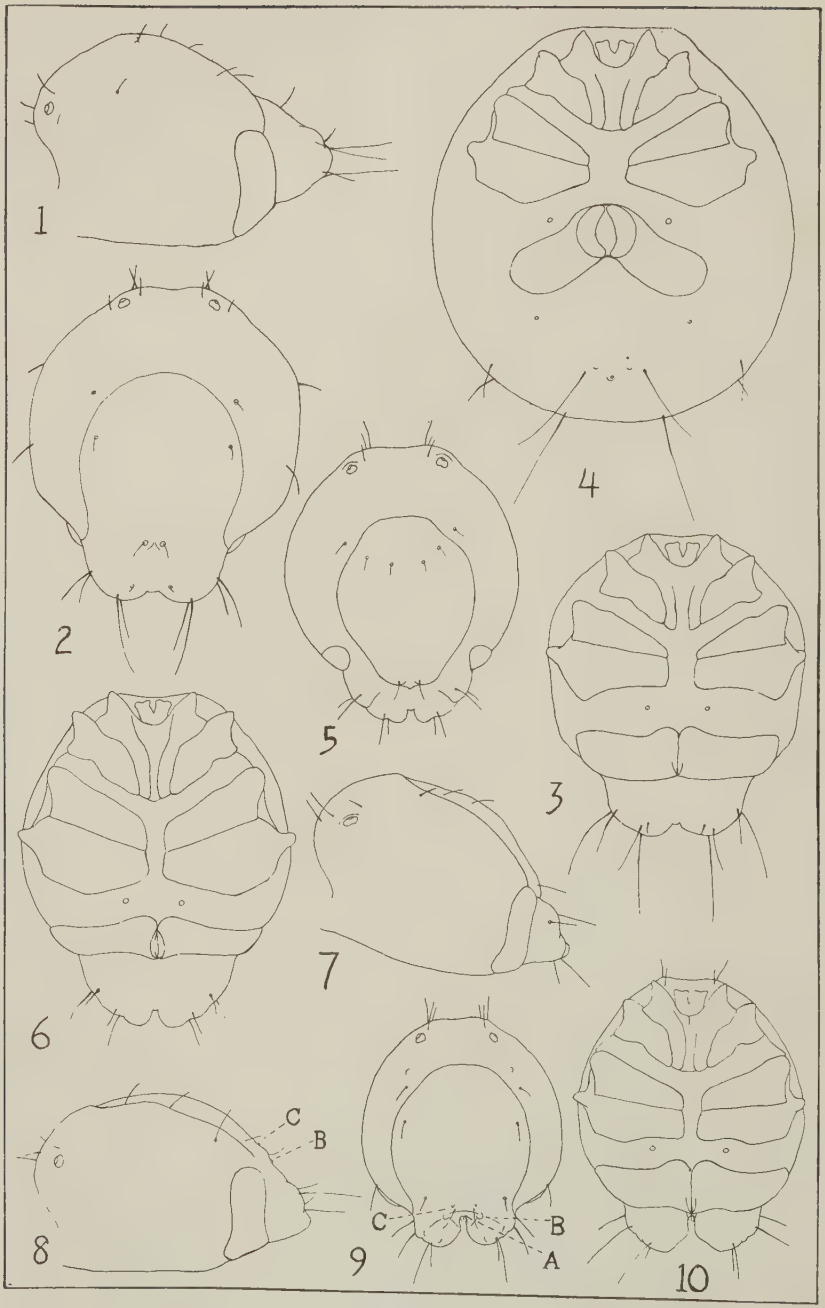
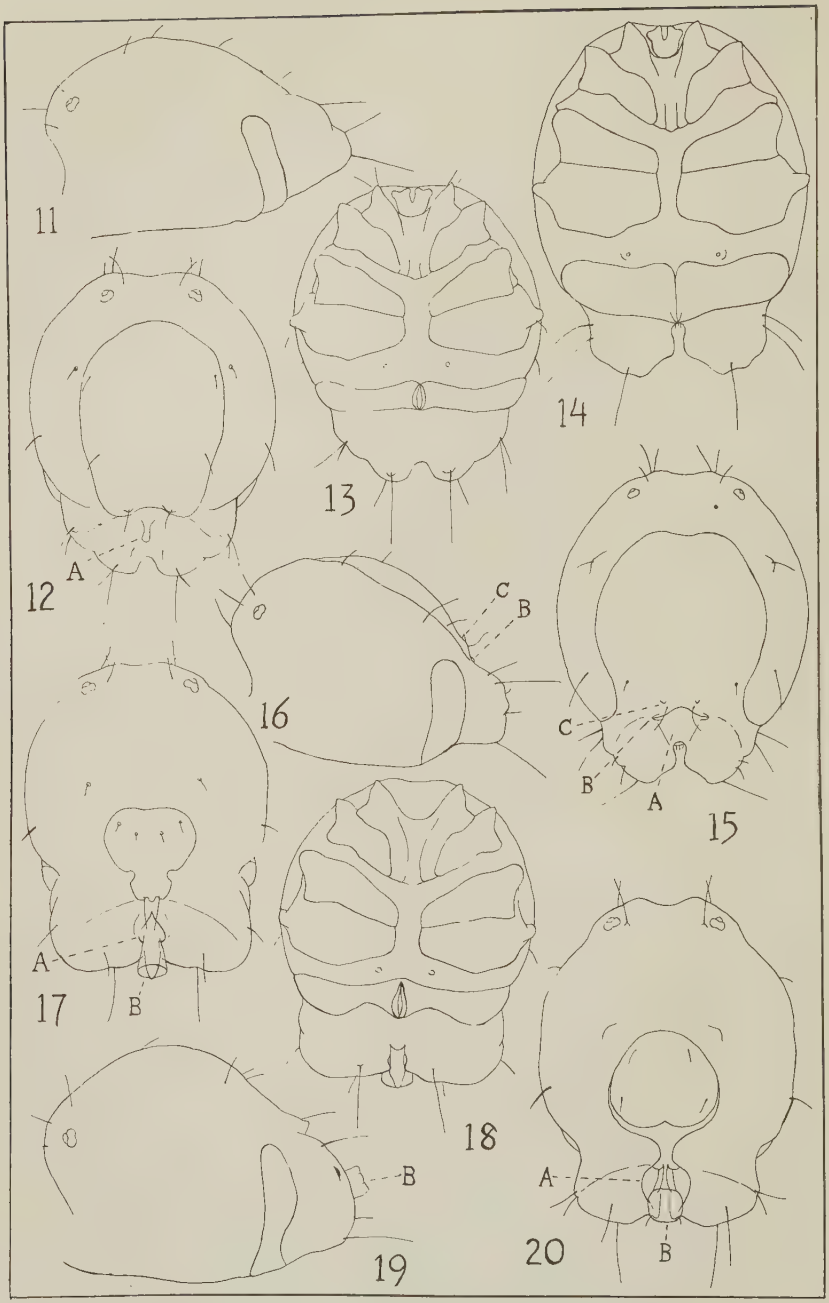


PLATE VIII



EXPLANATION OF PLATES

Plate VII

FIG. 1. *Arrhenurus rotundus,* lateral view.
FIG. 2. *Arrhenurus rotundus,* dorsal view.
FIG. 3. *Arrhenurus rotundus,* ventral view.
FIG. 4. *Arrhenurus rotundus,* fem., ventral view.
FIG. 5. *Arrhenurus ovalis,* dorsal view.
FIG. 6. *Arrhenurus ovalis,* ventral view.
FIG. 7. *Arrhenurus ovalis,* lateral view.
FIG. 8. *Arrhenurus bicaudatus,* lateral view.
FIG. 9. *Arrhenurus bicaudatus,* dorsal view.
FIG. 10. *Arrhenurus bicaudatus,* ventral view.
A, triangular depression on the appendix; B, rounded projections; C, point.

Plate VIII

FIG. 11. *Arrhenurus crenellatus,* lateral view.
FIG. 12. *Arrhenurus crenellatus,* dorsal view.
FIG. 13. *Arrhenurus crenellatus,* ventral view.
A, peg-like structure on the appendix.
FIG. 14. *Arrhenurus acutus,* ventral view.
FIG. 15. *Arrhenurus acutus,* dorsal view.
FIG. 15. *Arrhenurus acutus,* lateral view.
A, triangular depression on the appendix; B, rounded projection; C, point.
FIG. 17. *Arrhenurus scutulatus,* dorsal view.
FIG. 18. *Arrhenurus scutulatus,* ventral view.
FIG. 19. *Arrhenurus scutulatus,* lateral view.
A, heart-shaped depression; B, petiole.
FIG. 20. *Arrhenurus infundibularis,* dorsal view.
A, depression; B, petiole.

Plate IX

FIG. 21. *Arrhenurus infundibularis,* lateral view.
FIG. 22. *Arrhenurus infundibularis,* ventral view.
B, petiole.
FIG. 23. *Arrhenurus laticaudatus,* lateral view.
FIG. 24. *Arrhenurus laticaudatus,* dorsal view.
FIG. 25. *Arrhenurus laticaudatus,* ventral view (the specimen tipped forward).
A, humps on the dorsal shield; B, elevated corners of the appendix; C, hollow in which lies the petiole; D, crease.
FIG. 26. *Arrhenurus lyriger,* dorsal view.
A, rounded projections; B, hyaline structure; C, petiole.
FIG. 128. *Arrhenurus rotundus,* fourth leg.

Plate X

FIG. 27. *Arrhenurus lyriger,* ventral view.
FIG. 28. *Arrhenurus lyriger,* lateral view.
C, petiole.
FIG. 29. *Arrhenurus montifer,* lateral view.
FIG. 30. *Arrhenurus montifer,* ventral view.
FIG. 31. *Arrhenurus montifer,* dorsal view.
A, base of petiole; B, obliquely placed rod; C, vertical plate.
FIG. 32. *Arrhenurus mamillanus,* dorsal view.
FIG. 33. *Arrhenurus mamillanus,* end of the appendix.
FIG. 34. *Arrhenurus mamillanus,* lateral view.
A, B, C, transparent structures.

PLATE IX

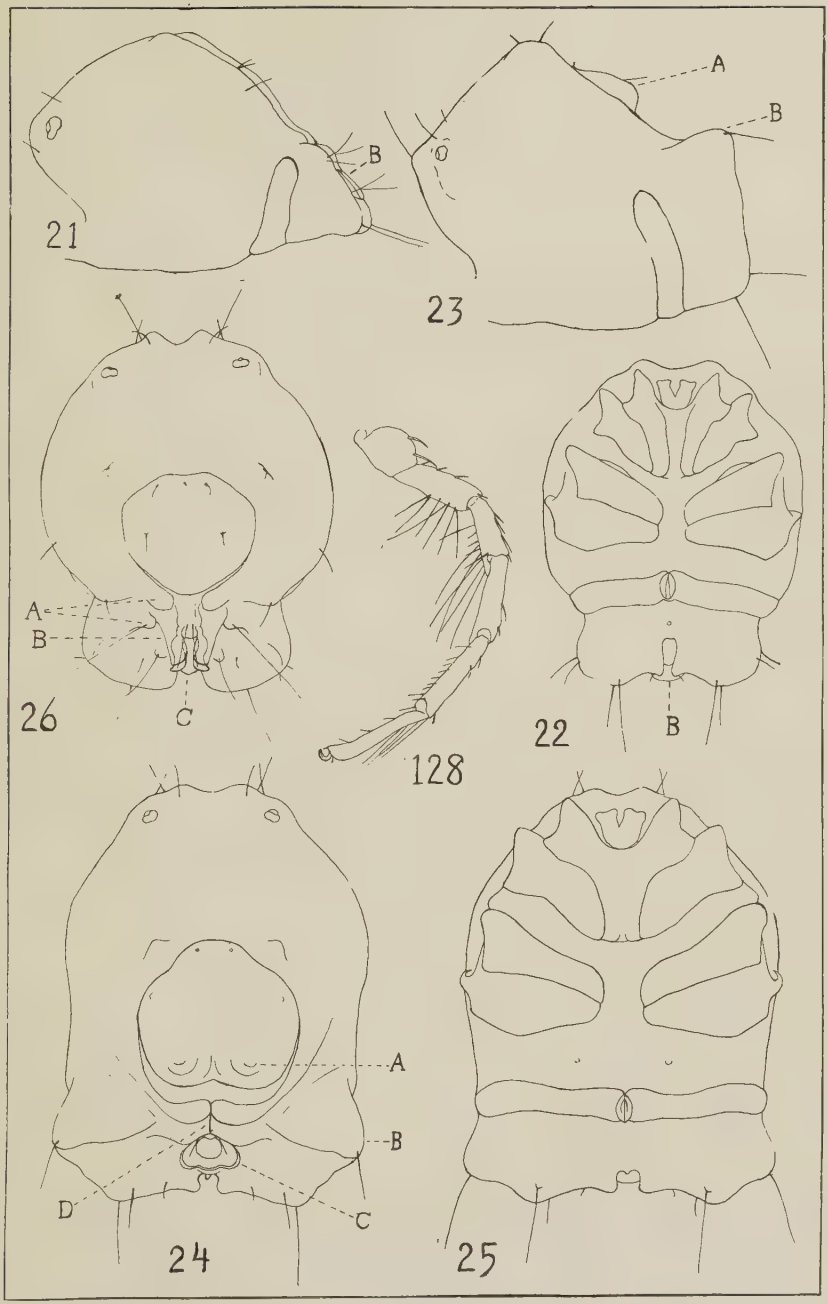


PLATE X

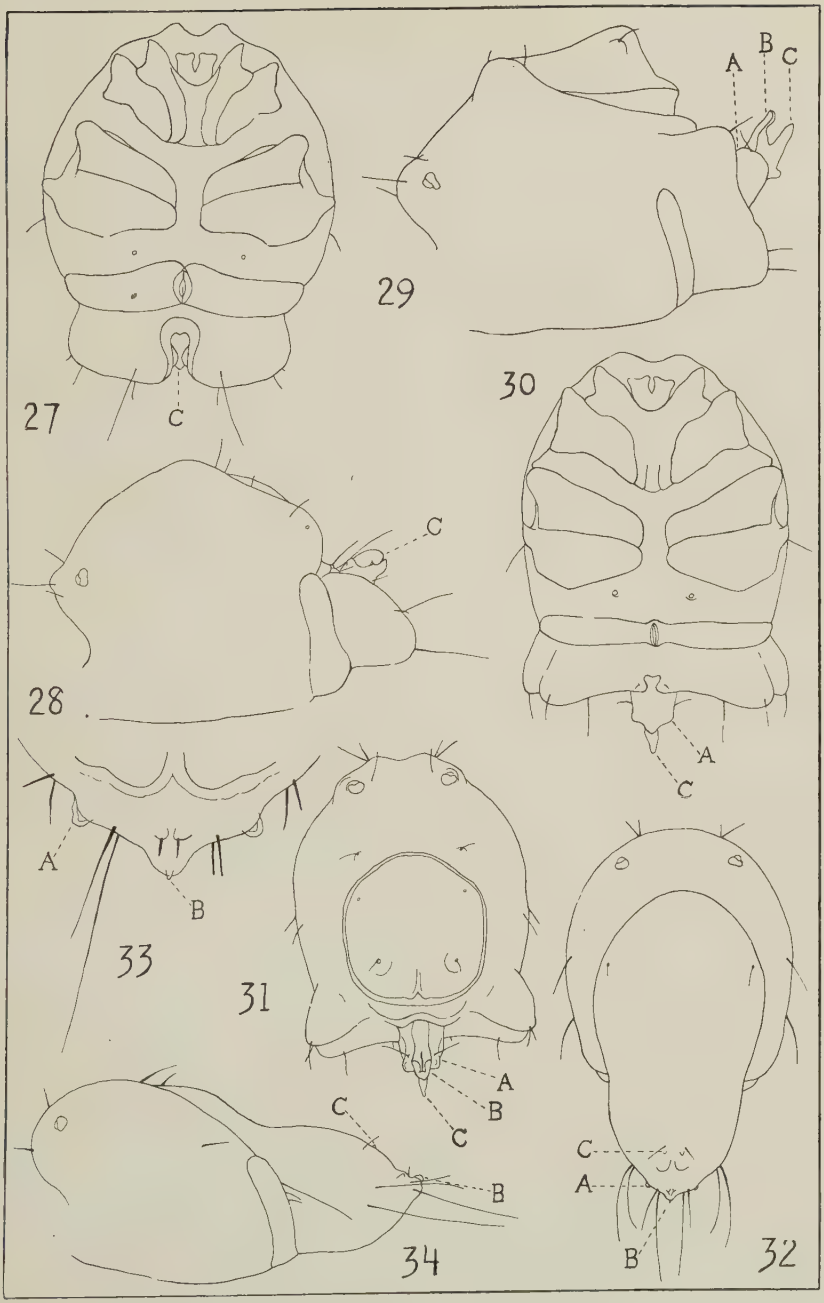
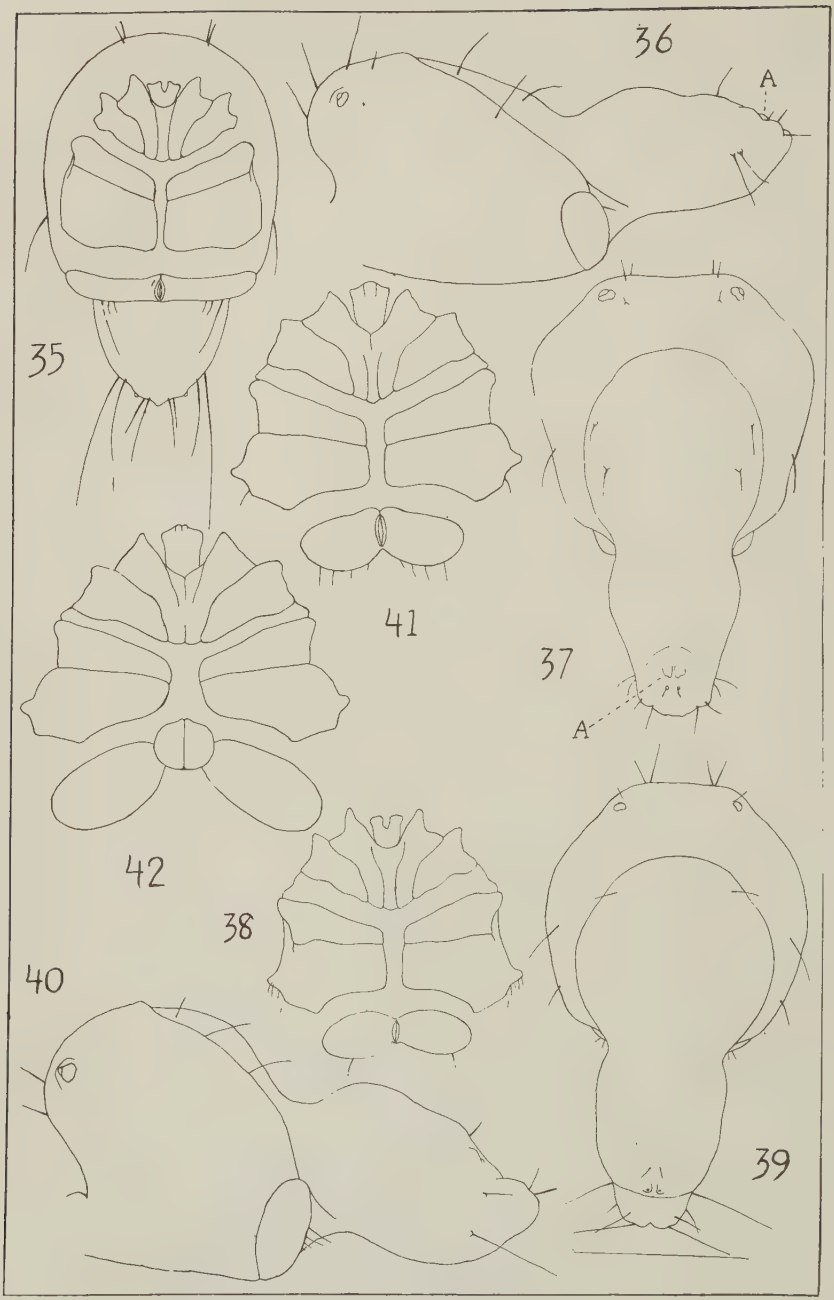


PLATE XI



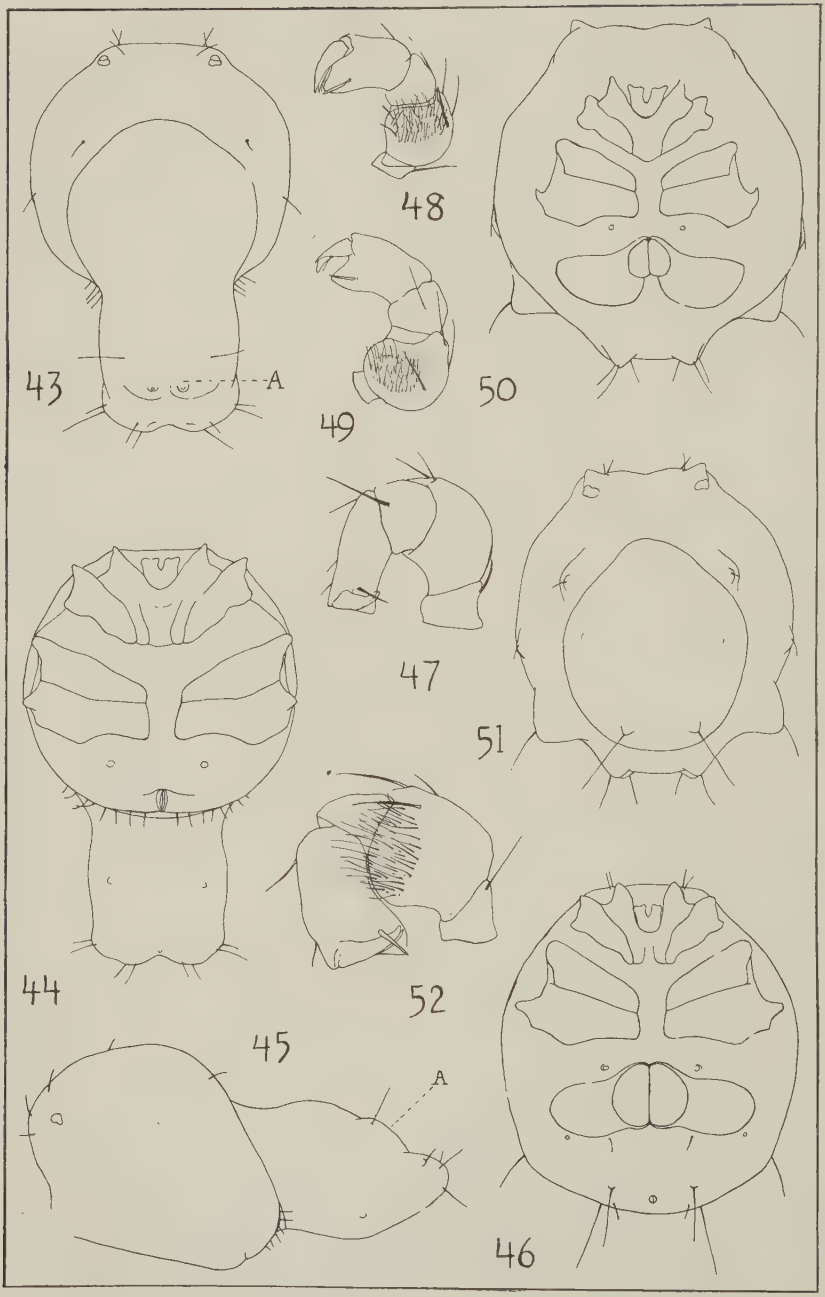

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PLATE XIII

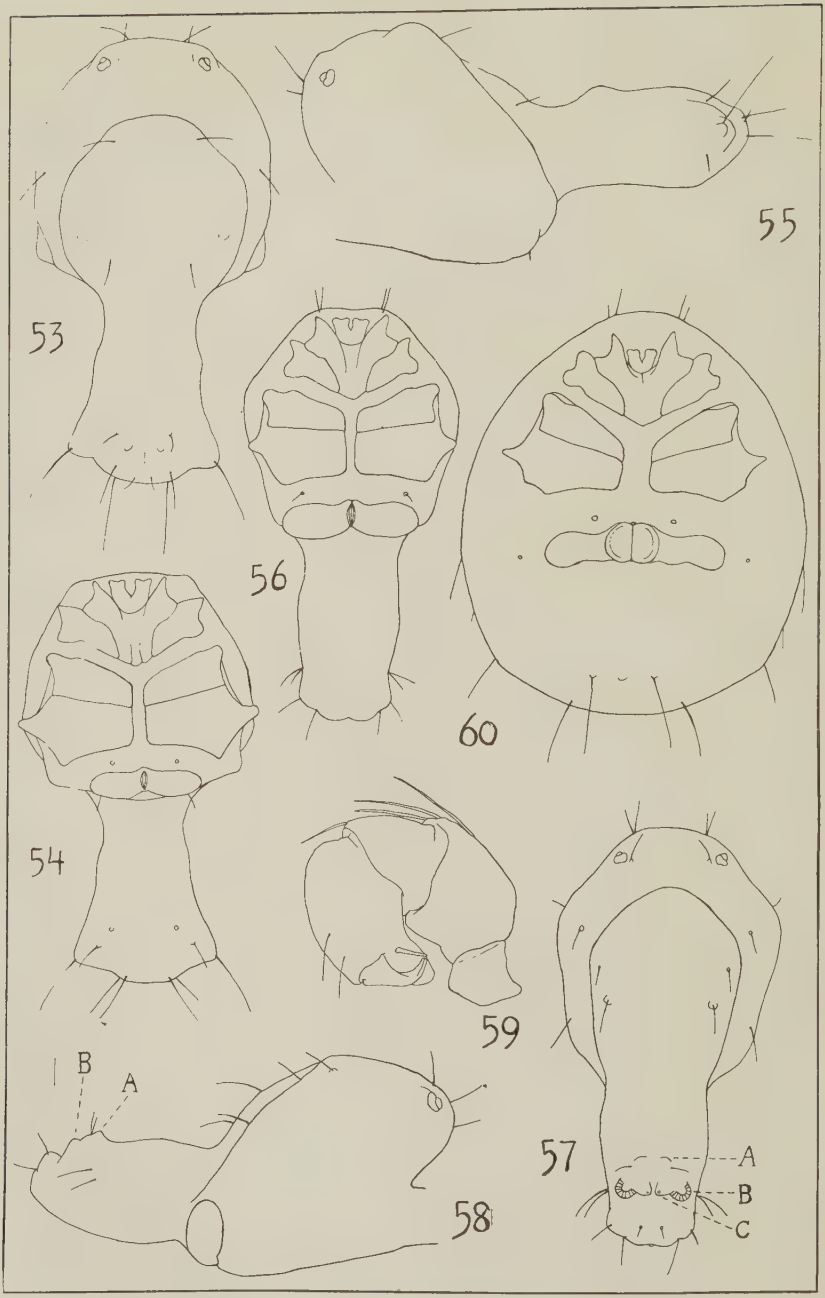


Plate XI

FIG. 35. *Arrhenurus mamillanus,* ventral view.
FIG. 36. *Arrhenurus solifer,* lateral view.
FIG. 37. *Arrhenurus solifer,* dorsal view.
FIG. 38. *Arrhenurus solifer,* epimera and genital field.
A, small elevations.
FIG. 39. *Arrhenurus scutuliformis,* dorsal view.
FIG. 40. *Arrhenurus scutuliformis,* lateral view.
FIG. 41. *Arrhenurus scutuliformis,* mas., epimera and genital field.
FIG. 42. *Arrhenurus scutuliformis,* fem., epimera and genital field.

Plate XII

FIG. 43. *Arrhenurus capillatus,* dorsal view.
FIG. 44. *Arrhenurus capillatus,* ventral view.
FIG. 45. *Arrhenurus capillatus,* lateral view.
A, humps.
FIG. 46. *Arrhenurus manubriator,* fem., ventral view.
FIG. 47. *Arrhenurus manubriator,* fem., right palpus.
FIG. 48. *Arrhenurus marshalli,* mas., right palpus.
FIG. 49. *Arrhenurus marshalli,* fem., right palpus.
FIG. 50. *Arrhenurus megalurus,* fem., ventral view.
FIG. 51. *Arrhenurus megalurus,* fem., dorsal view.
FIG. 52. *Arrhenurus megalurus,* fem., right palpus.

Plate XIII

FIG. 53. *Arrhenurus expansus,* dorsal view.
FIG. 54. *Arrhenurus expansus,* ventral view.
FIG. 55. *Arrhenurus expansus,* lateral view.
FIG. 56. *Arrhenurus prominulus,* ventral view.
FIG. 57. *Arrhenurus prominulus,* dorsal view.
FIG. 58. *Arrhenurus prominulus,* lateral view.
FIG. 59. *Arrhenurus prominulus,* palpus.
FIG. 60. *Arrhenurus prominulus,* fem., ventral view.
A, B, C, humps.

Plate XIV

FIG. 61. *Arrhenurus rectangularis,* ventral view.
FIG. 62. *Arrhenurus rectangularis,* dorsal view.
FIG. 63. *Arrhenurus rectangularis,* lateral view.
A, B, C, humps.
FIG. 64. *Arrhenurus semicircularis,* fourth leg.
FIG. 65. *Arrhenurus longicaudatus,* dorsal view.
FIG. 66. *Arrhenurus longicaudatus,* lateral view.
FIG. 66. *Arrhenurus longicaudatus,* epimera and genital field.
A, peg.
FIG. 68. *Arrhenurus cornicularis,* dorsal view.
FIG. 69. *Arrhenurus cornicularis,* lateral view.
FIG. 70. *Arrhenurus cornicularis,* epimera and genital field.
A, conical projections; B, C, knobs; D, point.

Plate XV

FIG. 71. *Arrhenurus apetiolata,* fem., ventral view.
FIG. 72. *Arrhenurus trifoliatus,* dorsal view.
FIG. 73. *Arrhenurus trifoliatus,* ventral view.
FIG. 74. *Arrhenurus trifoliatus,* lateral view.
FIG. 75. *Arrhenurus planus,* ventral view.
FIG. 76. *Arrhenurus planus,* dorsal view.
A, petiole.

Plate XVI

FIG. 77. *Arrhenurus angustocaudatus,* dorsal view.
FIG. 78. *Arrhenurus angustocaudatus,* ventral view.
FIG. 79. *Arrhenurus angustocaudatus,* lateral view.
A, hyaline appendage; B, thickened portion of the petiole; C, rolled-up outer portion.
FIG. 80. *Arrhenurus pseudocylindratus,* palpus.
FIG. 81. *Arrhenurus dentipetiolatus,* dorsal view.
A, outgrowth from the dorsal surface; B, hyaline appendage; C, tooth-like structure of the petiole.

PLATE XIV

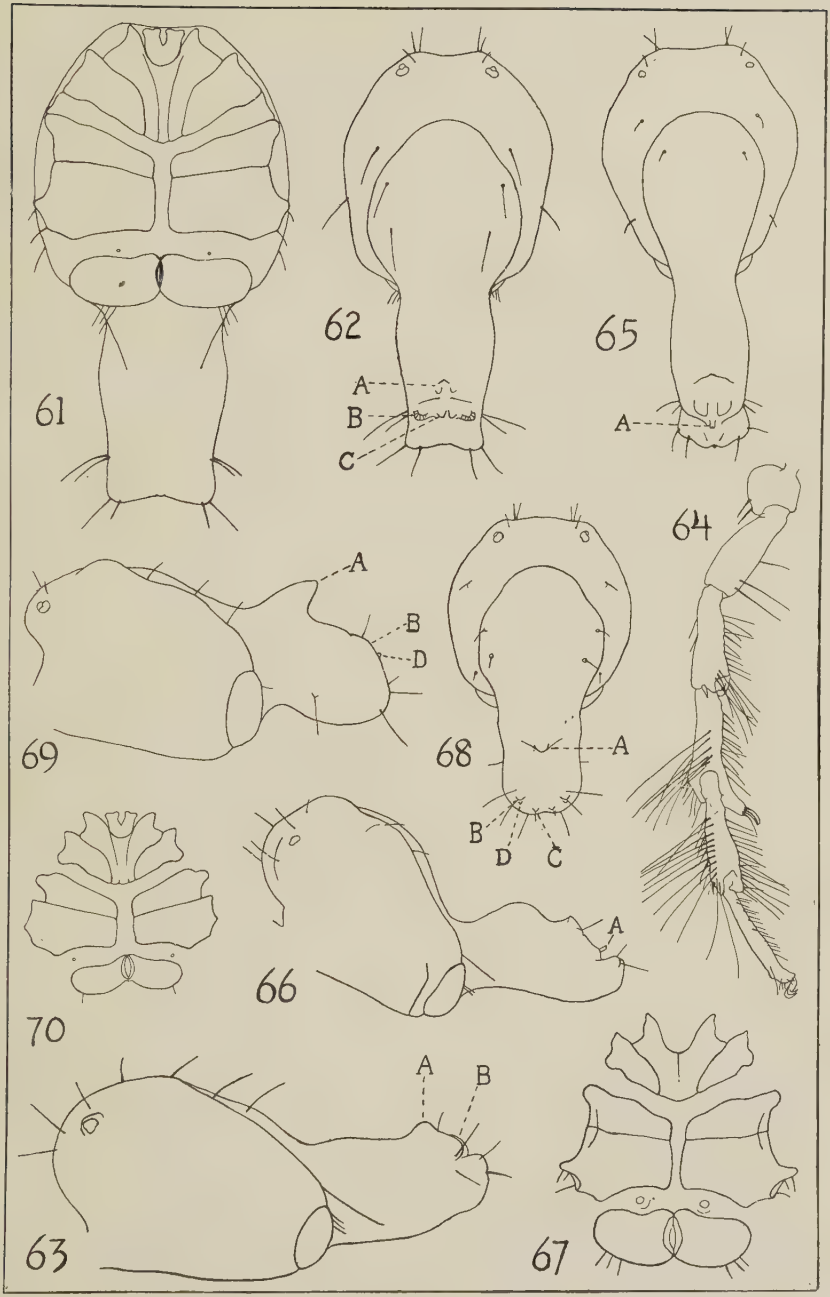
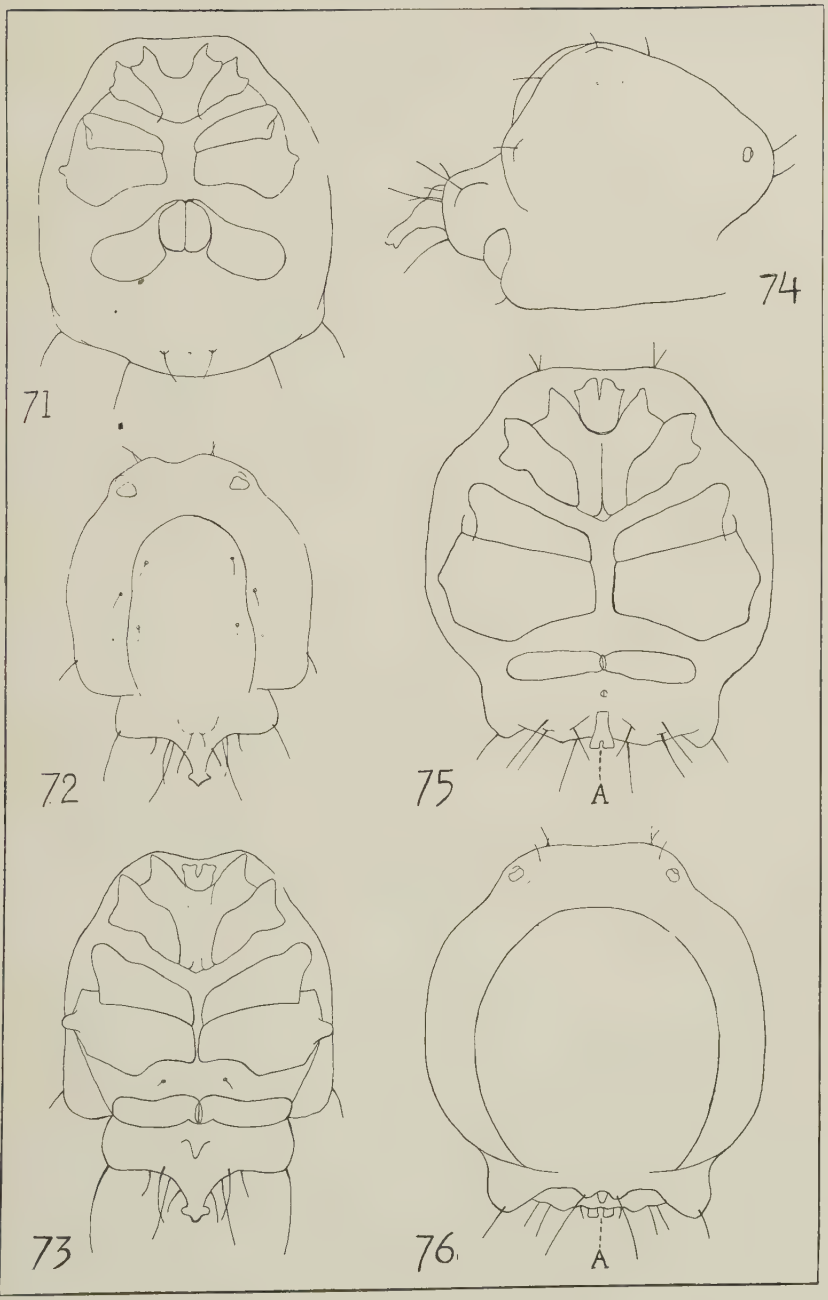


PLATE XV



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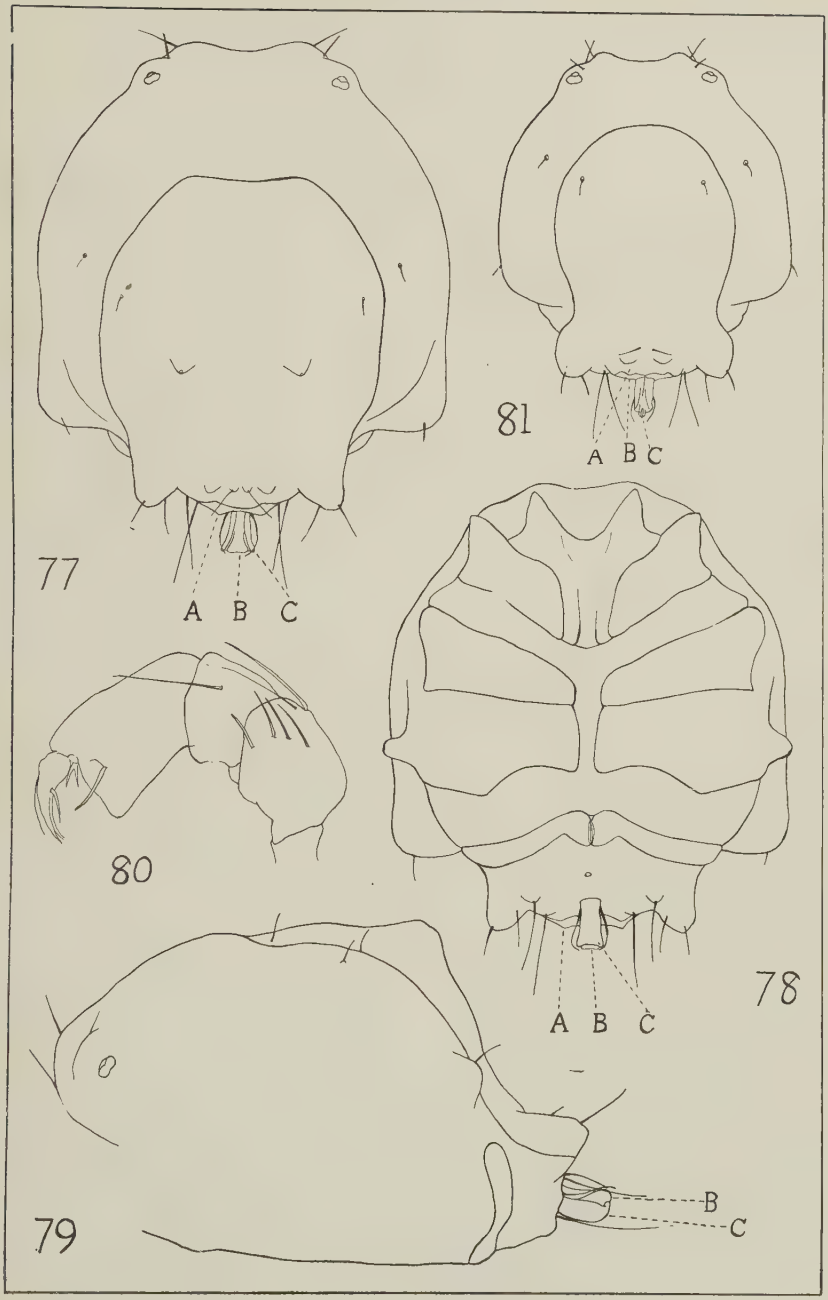

PLATE XVII

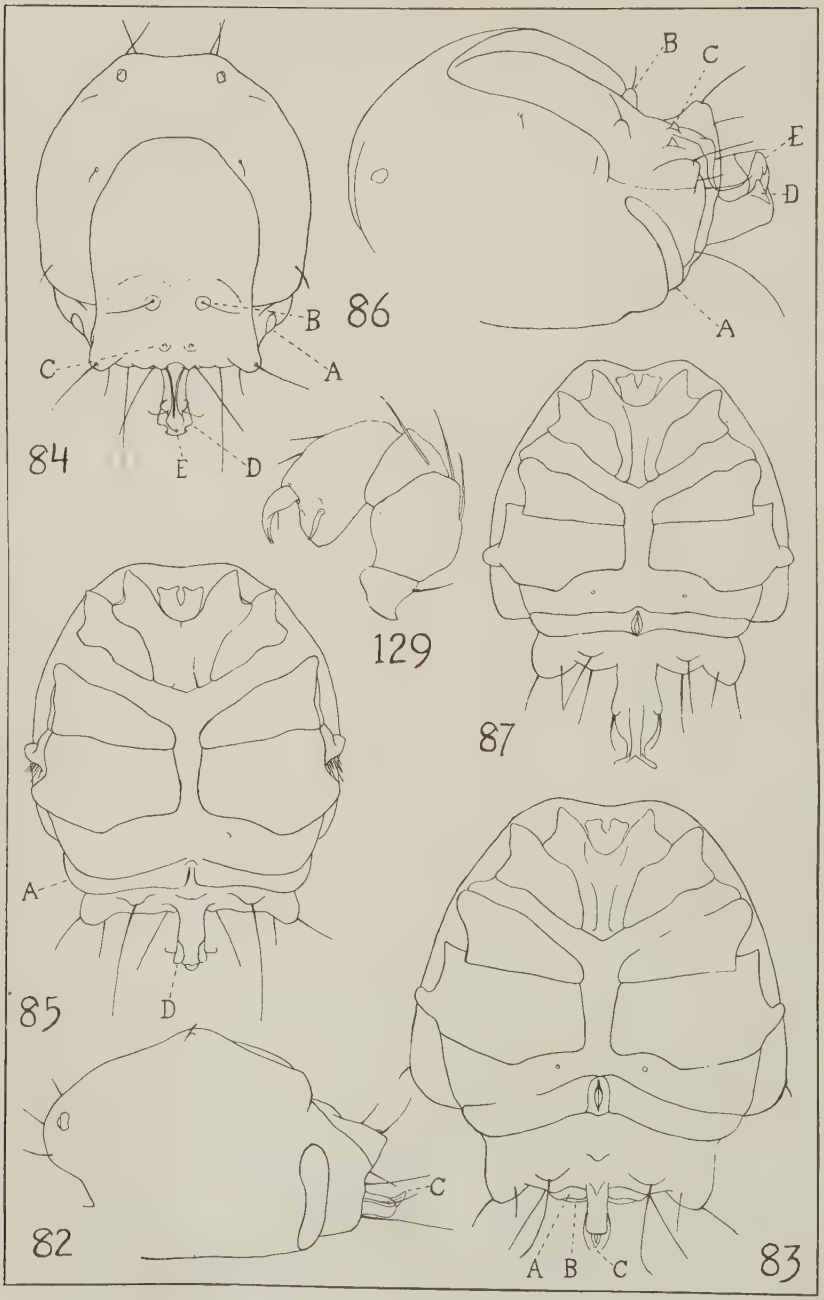

PLATE XVIII

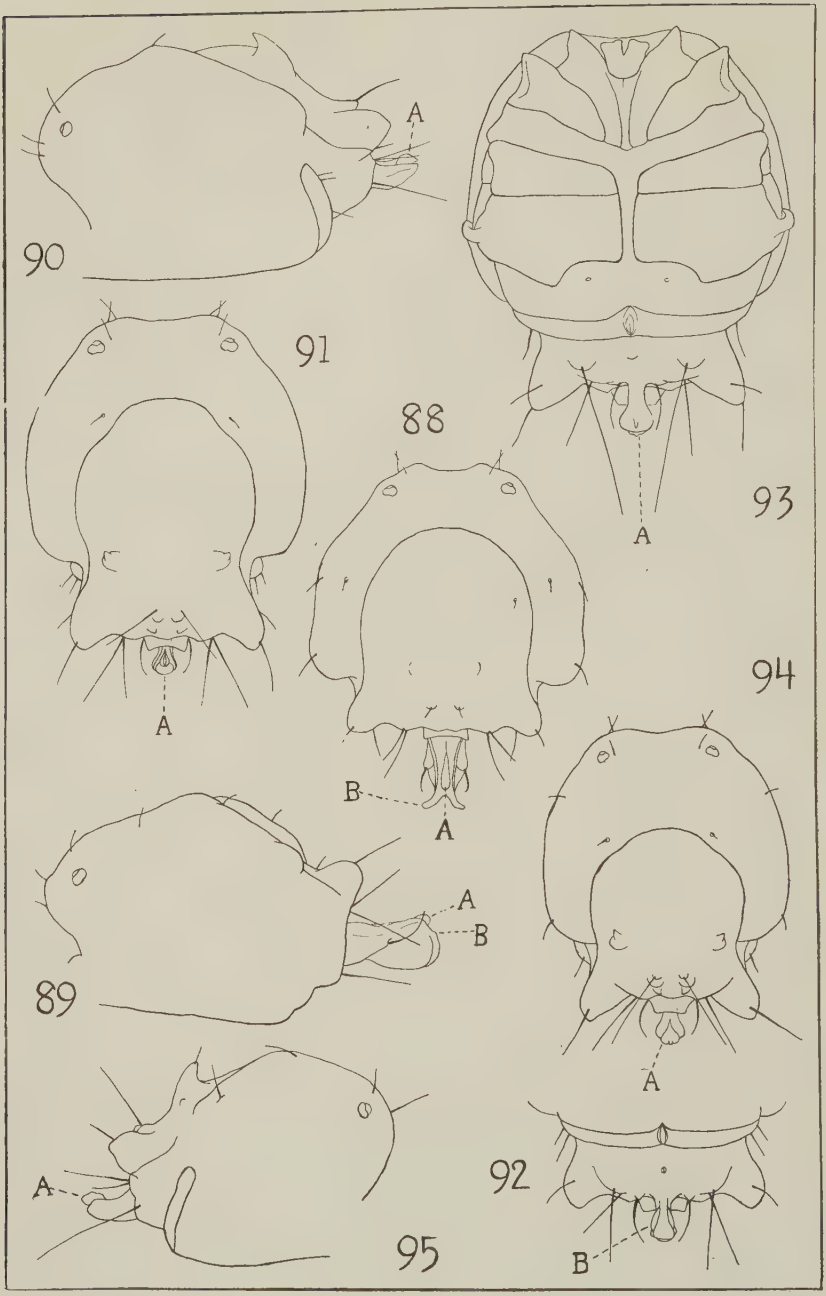

PLATE XIX

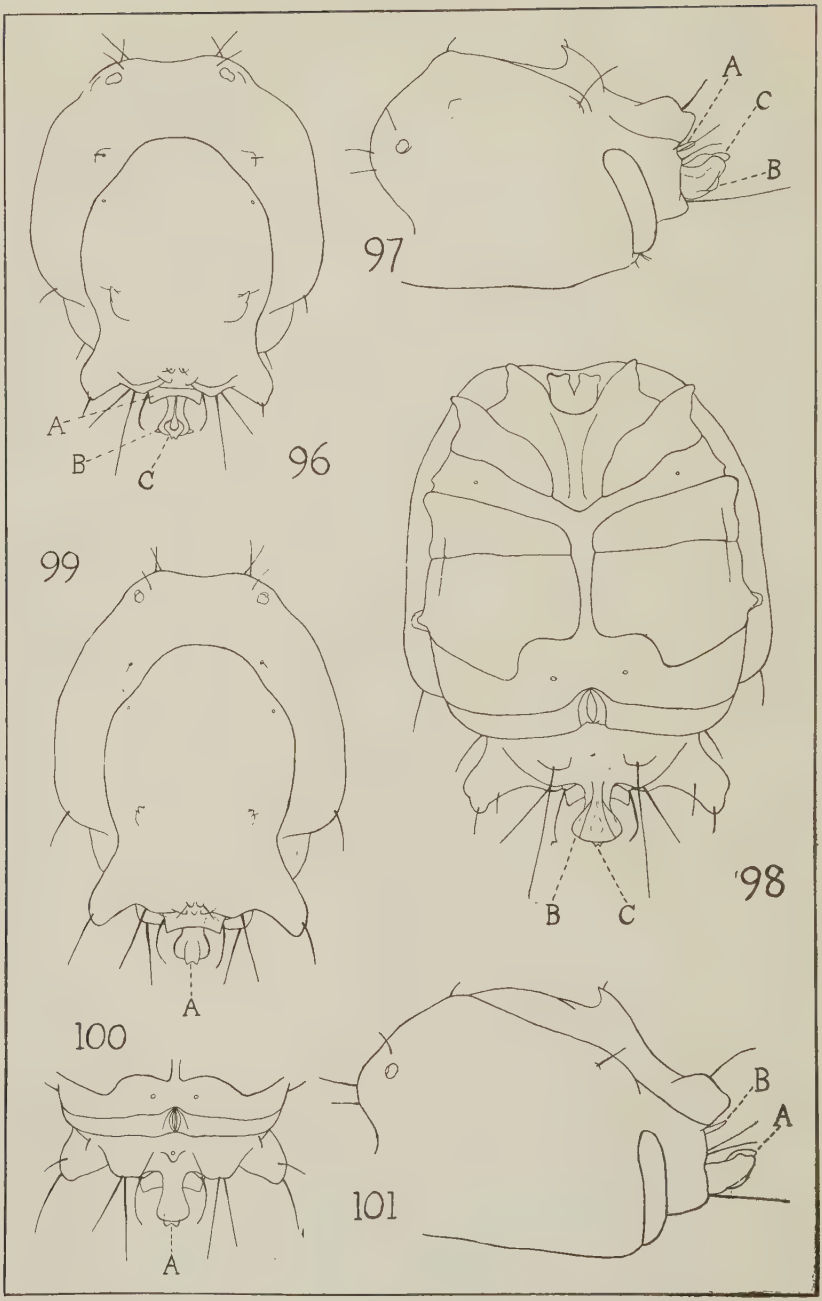

Plate XVII

FIG. 82. *Arrhenurus dentipetiolatus,* lateral view.
FIG. 83. *Arrhenurus dentipetiolatus,* ventral view.
A, outgrowth from the dorsal surface; B, hyaline appendage; C, tooth-like structure of the petiole.
FIG. 84. *Arrhenurus reflexus,* dorsal view.
FIG. 85. *Arrhenurus reflexus,* ventral view.
FIG. 86. *Arrhenurus reflexus,* lateral view.
A, genital wing; B, circular hump; C, tooth-like structure; D, transparent corner of petiole; E, reflexed central part of the petiole.
FIG. 87. *Arrhenurus wolcotti,* ventral view.
FIG. 129. *Arrhenurus semicircularis,* palpus.

Plate XVIII

FIG. 88. *Arrhenurus wolcotti,* dorsal view.
FIG. 89. *Arrhenurus wolcotti,* lateral view.
A, bladder-like structure; B, prongs of the petiole.
FIG. 90. *Arrhenurus pistillatus,* lateral view.
FIG. 91. *Arrhenurus pistillatus,* dorsal view.
FIG. 92. *Arrhenurus pistillatus,* ventral view of the appendix.
A, rounded bladder-like structure; B, elongated bladder-like piece.
FIG. 93. *Arrhenurus compactilis,* ventral view.
FIG. 94. *Arrhenurus compactilis,* dorsal view.
FIG. 95. *Arrhenurus compactilis,* lateral view.
A, leaf-like structure.

Plate XIX

FIG. 96. *Arrhenurus falcicornis,* dorsal view.
FIG. 97. *Arrhenurus falcicornis,* lateral view.
FIG. 98. *Arrhenurus falcicornis,* ventral view.
A, hyaline appendage; B, elongated bladder-like structure; C, vase-shaped structure.
FIG. 99. *Arrhenus laticornis,* dorsal view.
FIG. 100. *Arrhenurus laticornis,* ventral view of the appendix.
FIG. 101. *Arrhenurus laticornis,* lateral view.
A, bladder-like structure; B, hyaline appendage.

Plate XX

FIG. 102. *Arrhenurus amplus,* fem., ventral view.
FIG. 103. *Arrhenurus amplus,* lateral view..
FIG. 104. *Arrhenurus amplus,* ventral view.
FIG. 105. *Arrhenurus amplus,* dorsal view.
A, hyaline appendage.
FIG. 106. *Arrhenurus magnicaudatus,* dorsal view.
FIG. 107. *Arrhenurus magnicaudatus,* ventral view of the end of the appendix.
FIG. 108. *Arrhenurus magnicaudatus,* lateral view.
A, hyaline appendage.
FIG. 109. *Arrhenurus superior,* ventral view of the appendix.
FIG. 110. *Arrhenurus superior,* lateral view.
FIG. 111. *Arrhenurus superior,* dorsal view of the end of the appendix.
A, hyaline appendage.

Plate XXI

FIG. 112. *Arrhenurus americanus,* ventral view.
FIG. 113. *Arrhenurus americanus,* dorsal view.
FIG. 114. *Arrhenurus americanus,* lateral view.
FIG. 115. *Arrhenurus americanus,* palpus view.
FIG. 116. *Arrhenurus americanus,* fourth leg (the last three joints are rotated).
FIG. 117. *Arrhenurus americanus,* fem., ventral view.
FIG. 118. *Arrhenurus major,* dorsal view of the appendix of the intermediate form.
FIG. 119. *Arrhenurus major,* dorsal view.
FIG. 120. *Arrhenurus major,* lateral view.

Plate XXII

FIG. 121. *Arrhenurus major,* ventral view.
FIG. 122. *Arrhenurus flabellifer,* lateral view.
FIG. 123. *Arrhenurus flabellifer,* dorsal view.
FIG. 124. *Arrhenurus flabellifer,* ventral view.
A, thickened central part of the petiole.
FIG. 125. *Arrhenurus fissicornis,* dorsal view.
FIG. 126. *Arrhenurus fissicornis,* lateral view.
FIG. 127. *Arrhenurus fissicornis,* ventral view.
A, conical cleft hump; B, genital wing; C, hyaline appendage; D, transparent corner of the petiole; E, central spoon-shaped piece.

PLATE XX

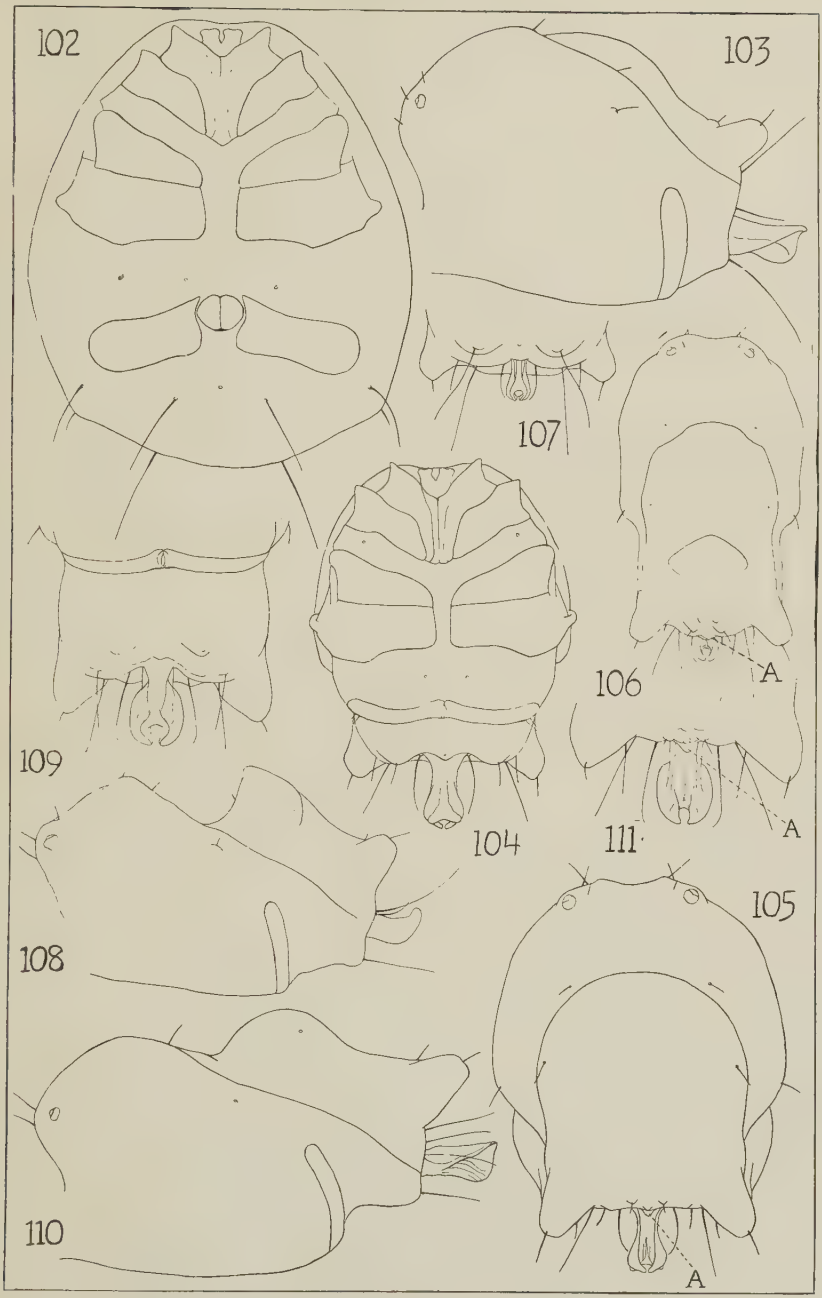

PLATE XXI

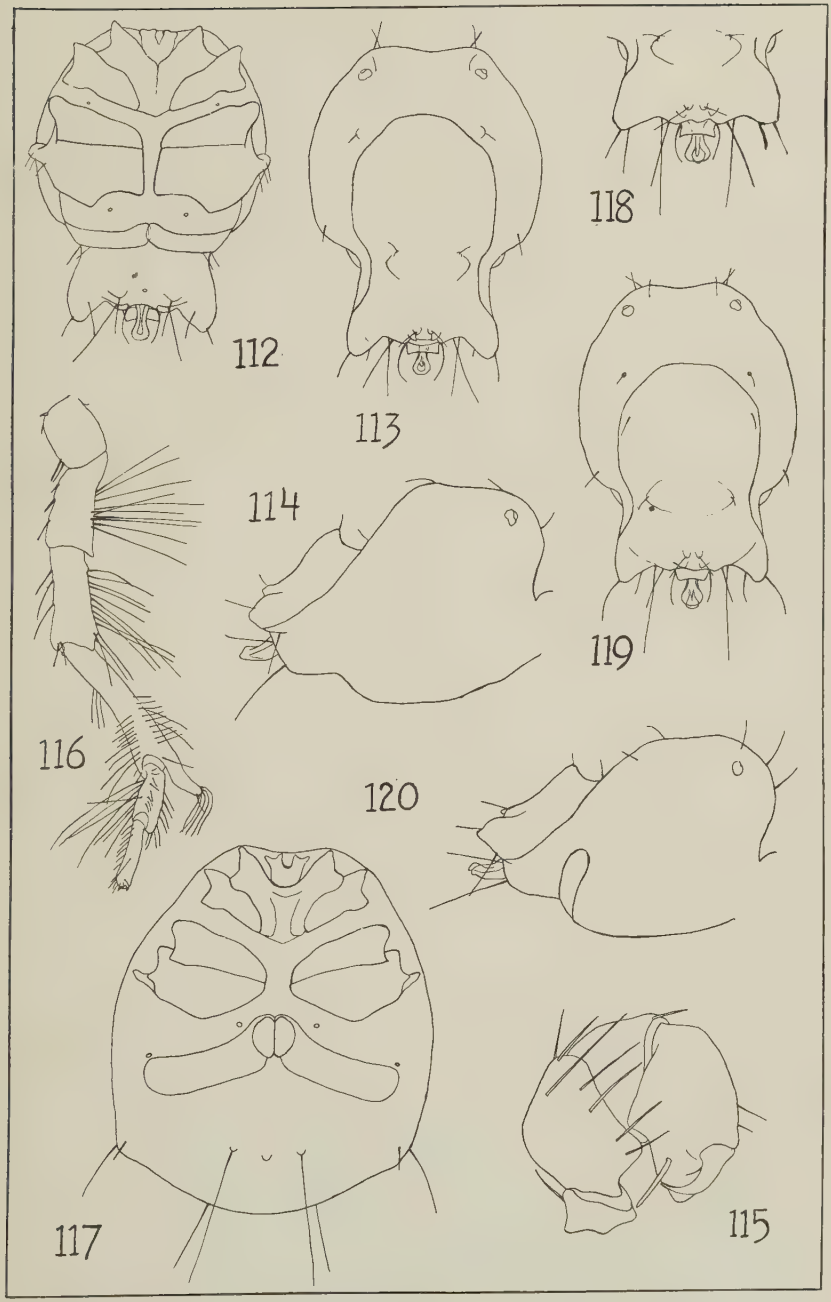
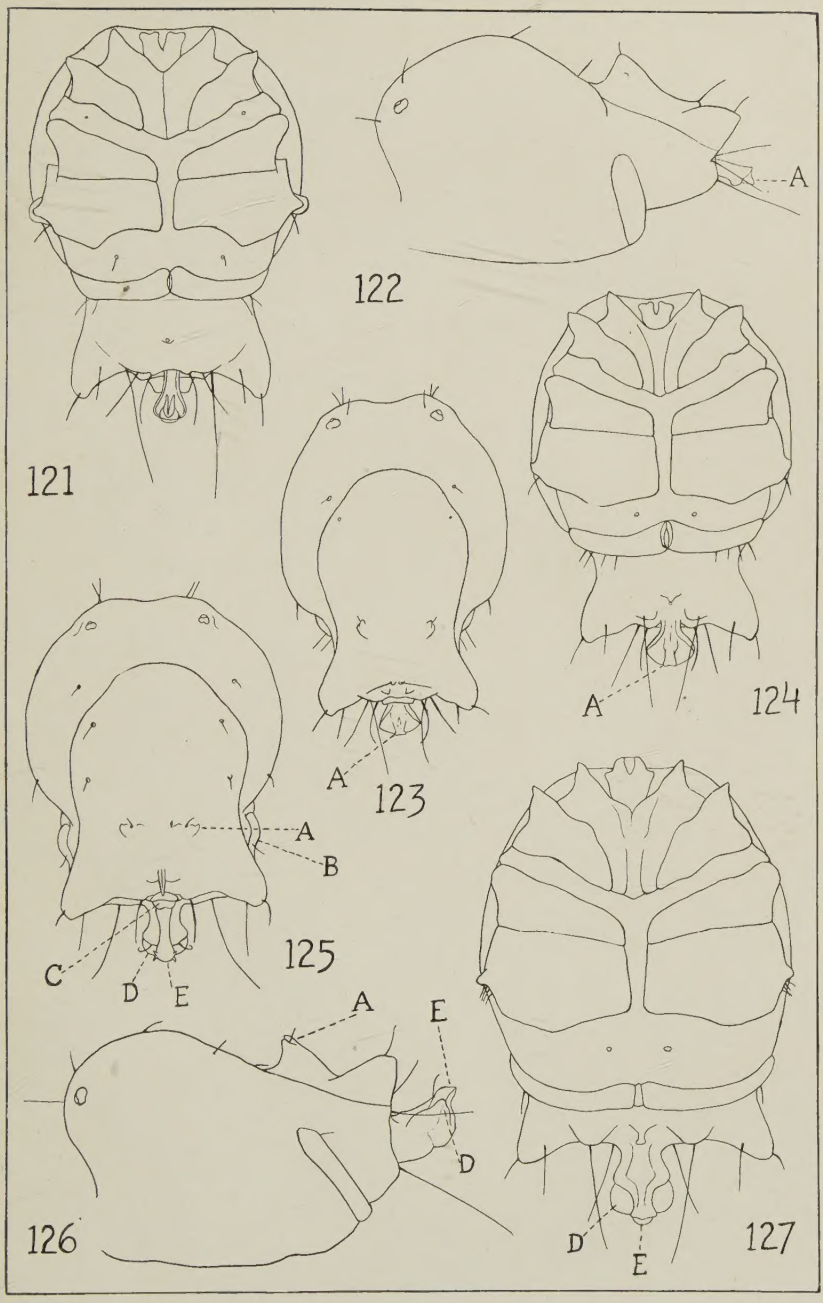
PLATE XXII